DEPARTMENT OF DEFENSE WEATHER PROGRAMS

The Department of Defense (DOD) operates a military environmental service system to provide specialized worldwide meteorological, space environmental and oceanographic analysis and prediction services in support of military forces. This system directly supports all phases of military operations, from strategic planning to tactical operations. While the Army and Marine Corps each have a small specialized weather support capability, the Naval Meteorology and Oceanography Command and Air Force Weather are the primary sources of military weather products. The military weather services contribute to the national and international weather observing capability by taking conventional observations on land and at sea where there are no other conventional weather observing capabilities and where the observations are most needed to meet military requirements. In addition, DOD maintains specialized observing capabilities, such as the Defense Meteorological Satellite and Global Weather Intercept Programs, to meet unique military requirements. Observational data are sent by military communications networks to military and civil facilities in the United States and overseas.

UNITED STATES AIR FORCE

METEOROLOGICAL SERVICES

Air Force Weather (AFW) provides high-quality, mission-tailored terrestrial and space environment observations, forecasts, and services to the United States Air Force (USAF), United States Army (USA), and a variety of United States Government (USG) departments and agencies. (See Section 3, United States Army, for details of AFW support to the Army.)

AIR FORCE WEATHER ORGANIZATION

AFW services and support are organized under the functional management of the Director of Weather (AF/XOO-W), Directorate of Operations and Training (AF/XOO), Deputy Chief of Staff for Air and Space Operations (AF/XO), Headquarters Air Force (HAF). The Director of Weather oversees USAF-wide training, organizing, and equipping of AFW units to include the following functions:

- Development of doctrine, policies, requirements, and standards for weather support
- Evaluation of weather support effectiveness
- Management of officer, enlisted, and civilian career fields
- Development and implementation of mid- to long-range plans for the organization, equipment, manpower, and technology necessary to meet future USAF and USA weather requirements
- Advising Air Staff and subordinate headquarters functional managers regarding manpower, career field, personnel utilization, training, operations policy and procedures, and technology acquisition
- Advocating and fielding standardized weather equipment

AFW, a Total Force organization, employs over 4,900 active and reserve component (Air Force Reserve (AFR) and Air National Guard (ANG)) military, civilian, and contract personnel at more than 290 locations worldwide. AFW's active component is organized to mirror the three levels of military operations: strategic, operational (theater), and tactical.

AFW's strategic weather units are centers of expertise for providing timely, accurate, and relevant strategic-level terrestrial and space weather products necessary to effectively plan and conduct military operations. The centerpiece of the strategic level, as well as the DOD Center of Excellence for meteorological satellite imagery, is the Air Force Weather Agency (AFWA), Offutt AFB, Nebraska, a field operating agency (FOA) reporting directly to AF/XOO-W. AFWA plans and produces a wide range of terrestrial and space weather products and provides dedicated climatology, strategic weather, and space environment forecast support to Special Operations Forces (SOF) and the National Intelligence Community (NIC). The

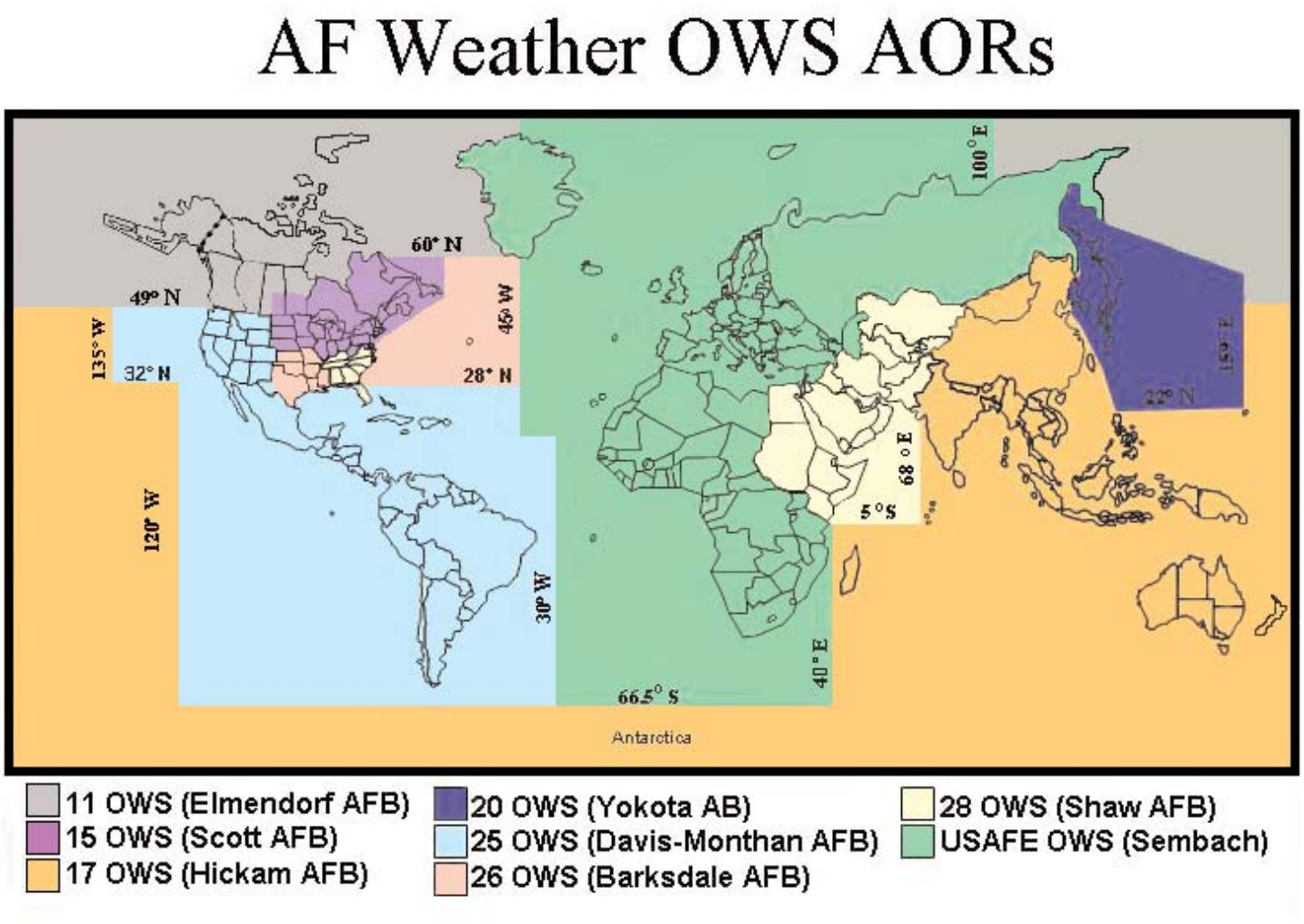

Figure 3-DOD-1. Areas of Responsibility for Air Force Weather's Operational Weather Squadrons.

agency consists of a strategic processing center collocated with a functional management headquarters, two subordinate centers (the Air Force Combat Climatology Center (AFCCC) and the Air Force Combat Weather Center (AFCWC)), and 17 detachments and operating locations. AFWA also provides backup support to five national weather centers. AFCCC, Asheville, North Carolina, provides centralized climatological database services, produces specialized weather-impact information for DOD and allied nations, and warehouses and distributes atmospheric science-related technical information. From Hurlburt Field, Florida, AFCWC transitions technology to tactical-level weather units while developing operational concepts and tactics, techniques, and procedures.

Eight Operational Weather Squadrons (OWS) form the backbone of AFW's operational level. Each OWS provides or arranges for operational-level weather forecast products and support for units assigned and/or deployed into its area of responsibility (AOR). These AORs are depicted in Figure 3-DOD-1. When collocated, OWS personnel also support the commander and staff of Numbered Air Forces (NAFs), Air Operations Centers (AOCs), and United States Army Echelons Above Corps (EAC). In addition, OWSs provide flight weather briefings to aircrews operating within their AOR without home station support or as requested by a tactical-level weather unit. Moreover, OWSs provide theater-scale, tailored environmental information to guide development of mission execution forecasts (MEF) by active and reserve component combat weather teams (CWTs). OWSs also produce and disseminate terminal aerodrome forecasts (TAFs), weather watches, warnings, and advisories, planning and execution area forecasts, and other operational products to CWTs and other users using the OWS Production System Phase II (OPS II). In addition to its dissemination function, OPS-II facilitates integration of strategic-level products and indigenous data to automatically and manually generate weather forecast products.

CWTs, located at base and post level, take and disseminate local observations and develop tailored MEFs at the tactical level based on centrally produced guidance. CWTs also act as "eyes forward" for OWSs. CWTs deploy with hand-held Kestral observ-

ing kits, the TMQ-53 semi-automated observing system for semi-permanent sites, and in some cases, tactical weather radars.

Approximately 100 weather personnel serve as AFR individual mobilization augmentees (IMAs) assigned to various active AFW units at all levels. IMAs typically train one day each month and for an additional two weeks each year.

The ANG traditional program consists of 33 weather flights, ranging in size from 13 to 25 personnel, who meet monthly to train for their wartime mission. These units provide weather information to Army National Guard and United States Army Reserve units as well as ANG flying units. In addition, the ANG performs peacetime weather operations at locations where the ANG is responsible for airfield support. The Weather Readiness Training Center (WRTC) at Camp Blanding, near Starke, Florida, is also operated by the ANG to provide Army tactical skills training not available elsewhere in the Air Force.

AFW is currently engaged in reengineering the AFR and ANG weather forces to more closely align operations with active duty forces. Total Force AFW personnel enhance the effectiveness of ground, air, and space operations worldwide by providing flight weather briefings, air/ground radio services, and tailored observations, forecasts, watches, warnings, and advisories.

AFW Five Core Processes

To fulfill its global mission of providing timely, accurate, and relevant weather information, AFW maintains and continually improves on its five core processes: data collection, analysis, forecasting, product tailoring, and dissemination. The following paragraphs provide more information on each of these areas.

Weather Data Collection. Weather data collection integrates the spectrum of remote and fixed sensors into a single meteorological sensing and instrumentation approach for battlefield and in-garrison operations. Data collection in the space environment is discussed in the Space Environmental Services section. AFW personnel take observations essential for effective military operations and for weather analysis and forecasting. Weather personnel at both AF and Army locations (fixed and tactical) make observations available to local users and transmit them to military and civil locations throughout the world. Upper air observations provide vital input to numerical weather analysis and prediction models. United States and foreign rawinsonde reports are primary sources and are supplemented with military and civilian pilot reports. The Observing System 21st Century (OS-21) program will provide a much-needed, state-of-the-art life-cycle replacement for Air Force observing equipment. OS-21 includes five different configurations: fixed, deployable, remote, manual, and upper air. The manual configuration is intended for tactical operations and continues the improvements begun under the Manual Observing System and Tactical Meteorological Observing System Modification programs. AFW began fielding the fixed-base automated observing system and will continue to do so over the next 2-3 years. The remaining configurations will be upgraded or replaced after fielding of fixed-base automated systems nears completion.

Weather radar data is a principal source of information needed to produce severe weather warnings. Within the Continental United States (CONUS), AFW uses the WSR-88D. DOD, the Federal Aviation Administration (FAA), and DOC/NWS operate and maintain the WSR-88Ds within CONUS, and the AF operates and maintains those overseas. The AF has begun a transition from stand-alone legacy Principal User Processors (PUPs) to the network-connected open architecture Open PUPs (OPUPs) at some local installations and at all United States-based OWSs, allowing these regional forecasting centers access to real-time WSR-88D radar data at locations for which they have remote forecasting responsibility. Tactical Weather Radars (TWR) provide a capability for worldwide military contingency operations at deployed locations and at select fixed locations overseas.

The Defense Meteorological Satellite Program (DMSP), which provides volumes of cloud, upper air, and space environmental data, is a vital source of global weather data used to support combat operations. On-board sensors provide AFWA and the Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC) with visible, infrared, and microwave imagery of the entire globe, temperature and moisture sounding data, electrically-charged particle fluxes, and other specialized space environment data. DMSP also supplies direct, real-time readout of regional imagery and mission-sensor data to DOD land-based and shipboard terminals located worldwide (Figure 3-DOD-2).

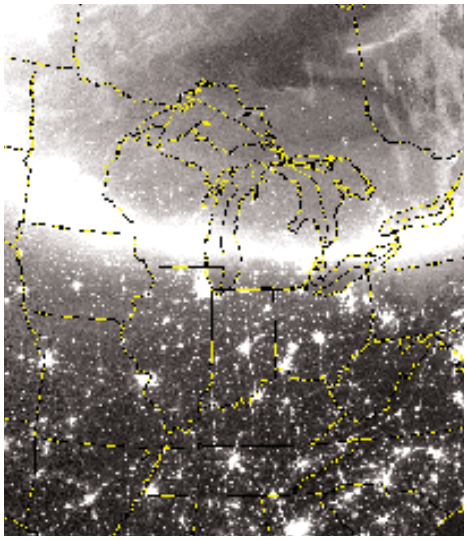

Figure 3-DOD-2. DMSP captures Aurora Borealis, over the midwest; the aurora was pushed toward the equator by a November 4, 2003 geomagnetic storm. (AFWeather website)

The present DMSP satellite series (Block 5D-2) uses the Operational Linescan System (OLS) to provide visible and infrared imagery to distinguish between clouds, ground, snow, and water. The DMSP also flies the Special Sensor Microwave temperature (SSM/T) and water vapor sounders (SSM/T-2). Processing algorithms convert the sensed data into vertical temperature, moisture, and height profiles of the atmosphere, providing key data for numerical analysis and forecasting. The Special Sensor Microwave Imager (SSM/I) observes rainfall, ocean surface wind speed, cloud and soil moisture, ice conditions, and other environmental data. The Special Sensor for Ions and Electrons (SSIES), Special Sensor Magnetometer (SSM), and the Precipitating Electron and Ion Spectrometer (SSJ), each providing vital inputs to space weather models, measure the space environment on the topside of the ionosphere in situ. The Block 5D-3 spacecraft began service in 2004 with the launch of DMSP Flight 16. These new spacecraft will add several new capabilities: enhanced microwave imaging and atmospheric temperature/moisture sounding through the Special Sensor Microwave Imager/ Sounder (SSMIS); new auroral boundary and electron density measuring capability through the Special Sensor Ultraviolet Spectrographic Imager (SSUSI); and profiles of upper-atmospheric temperature, electron content, and species densities through the Special Sensor Ultraviolet Limb Imager (SSULI).

AFW continues to participate in the refinement of requirements for the National Polar-orbiting Operational Environmental Satellite System (NPOESS). NPOESS will replace the existing DMSP and NOAA polar-orbiting satellite programs beginning in 2010 and is a joint DOD, DOC, and National Aeronautics and Space Administration (NASA) program. A new ground terminal system will also provide a direct readout capability for tactical users similar to that of the DMSP. AFW also expects to gain operational experience as well as benefit from the risk reduction planned with the NPOESS Preparatory Program planned for launch in 2006.

In addition to DMSP polar-orbiting data, AFWA receives stored data from the DOC's Polar-orbiting Operational Environmental Satellite constellation and real-time high-resolution data from the DOC's Geostationary Operational Environmental Satellite (GOES) East and West; the European Union's Meteosat-5, -7, and -8 geostationary satellites; and GOES 9, currently filling the Far East geostationary orbit until Japan launches the Multifunctional Transport Satellite (MTSAT). NESDIS receives test data files from India's INSAT-3A and KALPANA-1 (formerly METSAT-1) geostationary satellites. AFWA plans to accept this data via the Shared Processing Program (SPP) once data geolocation is improved to the appropriate level. AFWA currently receives data from NASA's Tropical Rainfall Measuring Mission (TRMM), Quick Scatterometer (QuikSCAT), and Moderate Resolution Imaging Spectroradiometer (MODIS) via the SPP.

To receive real-time visible, infrared, and microwave imagery and other non-imagery weather data from both polar-orbiting and geostationary satellites, AFW implemented the Joint METSAT Imagery, Software, and Terminals (JMIST) concept. JMIST leverages network and satellite communications, direct read-out terminals, and client applications to provide ready access and manipulation capabilities for advanced low-orbiting satellite imagery from numerous agencies, to include the USAF, United States Navy, and NASA.

The Air Force Reserve Command's 53rd Weather Reconnaissance Squadron (53 WRS), also known as the

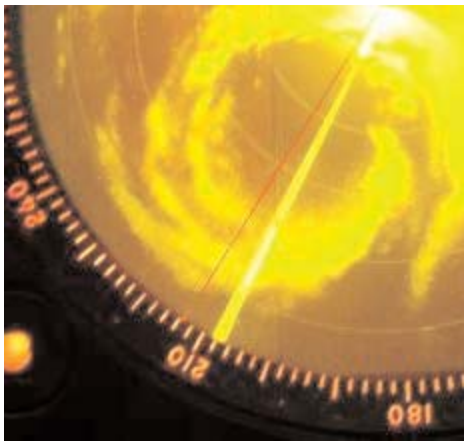

Figure 3-DOD-3. Aircraft radar shows the eye of Hurricane Claudette is 25 nautical miles wide and the wall cloud is weakest in the northeast quadrant (53 WRS website)

"Hurricane Hunters," provides another means of collecting vital meteorological data, especially in and around tropical cyclones. Their specially equipped WC-130 aircraft collect temperature, moisture, wind, pressure, and visually observed information at the aircraft location as well as vertical profiles of the atmosphere collected by dropsondes. Hurricane Hunter aircraft penetrate the eyes of tropical cyclones to provide the National Hurricane Center a very accurate center fix location as well as other meteorological parameters, including sea level pressure (Figure 3-DOD-3). In addition to the tropical cyclone reconnaissance mission, the 53 WRS collects meteorological information to improve wintertime West Coast forecasts and to support scientific field programs when possible. Visit 53 WRS web site at *http://www.hurricanehunters.com/*.

Analysis and Forecasting. AFWA is the AF's strategic production center for weather analyses and forecasts while the OWSs are the theater-scale production centers for AF and Army operations. AFWA uses networked computer systems and an interactive graphics and imagery system to implement a "build-and-apply" concept. Worldwide conventional weather data are relayed to AFWA and combined with civil and military meteorological

satellite data to construct a real-time, integrated environmental database. Computer programs further process the data to construct models of the atmosphere and forecast its future behavior. Manual tailoring of the data is critical for application to warfighters' specific needs. The interaction between forecaster and machine is accomplished using the Satellite Data Handling System (SDHS) at the strategic center, the OWS Production System (OPS-II) at the operational level, and the N-TFS at the tactical level.

AFWA has organized forecast operations to achieve greater flexibility and focus on primary missions. Forecasts are generated in the agency's Global Weather Center Division, which consists of four production branches: Special Support Operations, Space Weather, NIC Weather, and Meteorological Satellite Applications.

The Special Support Operations Branch (SSOB) acts as an OWS for SOF and provides worldwide mission-tailored forecasts to Joint SOF operations. The branch acts as a clearinghouse for unique data requests from the SOF community; provides tailored meteorological information for end-to-end special operations planning at United States Special Operations Command, component commands, and theater special operations commands. The SSOB is continually involved in global military operations to include Operations ENDURING FREEDOM and IRAQI FREEDOM. The SSOB generates a myriad of products ranging from air refueling forecasts, to detailed mission control forecasts, to weather impacts for SOF operations, and distributes this information via secure media. Additionally, the SSOB includes the American Forces Network Weather Center which provides worldwide, broadcast-quality public weather services and planning forecasts through the American Forces Radio and Television Service to over 800,000 DOD and Department of State personnel and family members stationed overseas.

The Space Weather Operations Center (Space WOC) provides worldwide general and tailored analyses, forecasts, advisories, and warnings of space weather phenomena that affect military operations and NIC activities. The Space WOC supports all DOD Services using space weather measurements from an integrated, global network of ground- and space-based sensors. Data sharing and forecast coordination exists between the NOAA Space Environment Center (SEC) in Boulder, Colorado, and the Space WOC and results in a synergistic capability to reach both military and civilian operators. Due to an increasing dependence on space-based systems such as precision-guided munitions, satellite communications, and modern guidance and radar systems, space environmental impacts are a key and growing field critical to military operations. The reliance on the Global Positioning Systems (GPS) and its vulnerability to ionospheric storms compel military planners and commanders to apply an awareness of space environmental information to all phases of military operations.

The NIC Weather Branch provides weather information that includes detailed global cloud analyses and forecasts to the intelligence community. The branch employs the NIC Weather Operations Cell that provides worldwide mission-tailored planning and execution forecasts for NIC agencies at security levels up to Top Secret/Sensitive Compartmented Information (TS/SCI). The branch also serves as the focal point for AFWA Special Access Program (SAP) requirements; ensures the NIC and other SCI and SAP meteorological requirements are integrated into AFWA programs; monitors and evaluates accuracy and timeliness of centralized weather services to the NIC; and interfaces with the DOD and NIC regarding weather services and exploitation of weather information.

The Meteorological Satellite (METSAT) Applications Branch provides operational imagery analyses production, technique development, technology insertion, and product improvement. The branch produces rapid response, tailored METSAT imagery and evaluation for DOD contingency operations and generates automated METSAT imagery products for web-based distribution to DOD users. The branch tracks and classifies tropical cyclones for the DOD Joint Typhoon Warning Center (JTWC) and the DOC National Hurricane Center; serves as the DOD focal point for volcanic ash plume detection, advisories, and trajectory forecasts; and provides hot back up for both JTWC satellite operations and the DOC's Washington Volcanic Ash Advisory Center. The METSAT Applications Branch produces worldwide snow and ice cover analyses to update and refine the snow depth database and also provides tailored snow depth and dust event analyses in contingency areas. During Operation IRAQI FREEDOM, branch imagery specialists provided high-resolution analyses of oil fire initiation points for smoke plume dispersion forecast model products. These smoke plumes impacted both air and land operations. Advance notice allowed mission planners to modify operations to maximize mission effectiveness. The branch also develops new capabilities to display and visualize satellite imagery on workstations and infuses state-of-the-art techniques into improved imagery analysis ensuring high-quality products.

The Global Theater Weather Analysis and Prediction System (GTWAPS) program has improved interaction of the strategic, operational-level, and tactical-level forecasting systems. The key software component of the GTWAPS program is a theater analysis and forecast model,

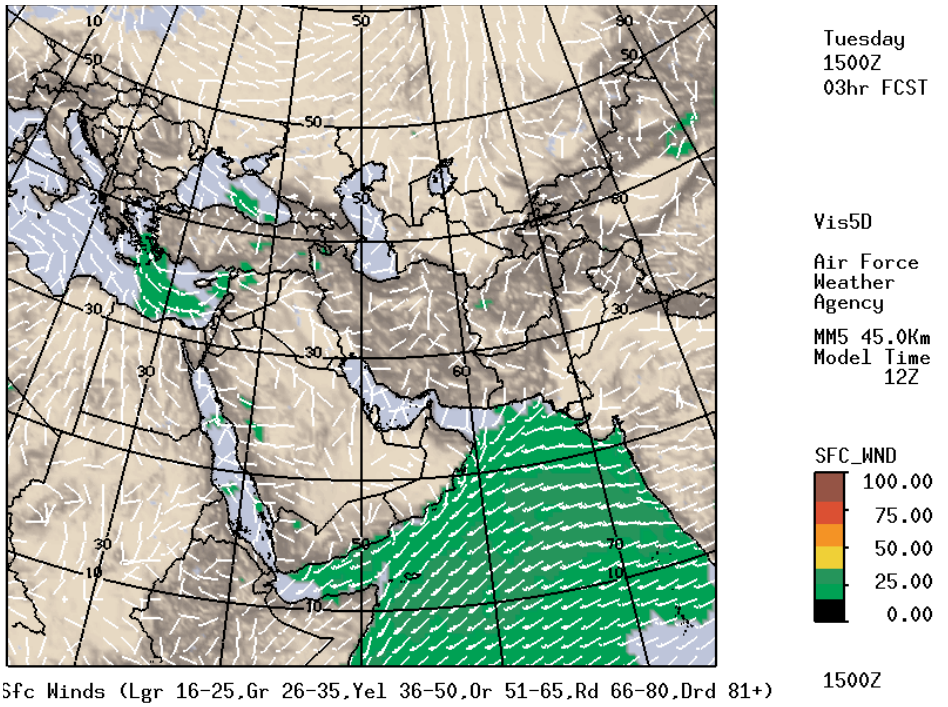

Figure 3-DOD-4. Joint Air Force and Army Weather Information Network (JAAWIN) provide reachback capability for deployed combat weather teams. This 3-hour forecast of surface winds over Southwest Asia was generated from AFWA's 45-km MM5 (AFWA Website)

Mesoscale Model version 5 (MM5), which provides fine-scale forecast data with improved accuracy (Figure 3-DOD-4). During Operations ENDURING FREEDOM and IRAQI FREEDOM, AFWA initiated various model window locations and resolutions as mission requirements dictated. The highly responsive nature of the MM5, and the way AFWA employs it, permitted new contingency windows to be operational within hours. Advancements in cloud modeling have enabled GTWAPS to produce high-resolution products that became a mainstay of weather data during the continuing global war on terrorism. Used by Predator Unmanned Aerial Vehicle (UAV), Global Hawk UAV, and space-based reconnaissance operators, these products allowed decision-makers to choose the most effective reconnaissance platform to maximize mission effectiveness. MM5 is routinely provided by AFWA to the NOAA National Centers for Environmental Prediction (NCEP), where it is a backup to their Eta model.

On-going modernization initiatives at AFWA include the Space Weather Analysis and Forecasting System (SWAFS) and the Weather Data Analysis (WDA) program. SWAFS will integrate additional space weather data sources and execute next-generation space weather models for DOD and NIC operations. WDA will continue the modernization of AFWA as the strategic center component of the Air Force Weather Weapon System (AFWWS). The reengineered AFWA will provide component-based and standards-compliant hardware, software tools, a central 4-D database, and a classified processing environment to modernize the AFWWS communications and data processing infrastructure. WDA provides a significant increase in the database capacity and capability by standing up Joint DOD approved METOC database segments that will begin an era of Common Operating Environment compliance and interoperability among data sharers.

WDA through the use of the METOC segments and the Joint METOC Broker Language for web services will improve the interoperability with DOD command and control (C2) and command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR) systems by providing a common interface to request the wide range of weather data and products. In addition WDA developed components (to include the Consolidated Dissemination Capability) are reusable within the OWS. This reusability will allow OWS-unique data to become part of the overall AFWWS 4-D database.

OWSs provide theater-scale battlespace forecasts; drop zone, range, and aerial refueling track forecasts; fine-scale target forecasts; and airfield forecasts and warnings for AF and Army installations within their AOR. Their primary tool is OPS-II, which ingests data and strategic center information, and creates and disseminates theater-scale products.

Product Tailoring/Warfighter Applications. Starting at the strategic level, AFW progressively focuses and tailors weather information, leading to individual mission-specific forecasts at the CWT level. For example, although still an emerging system, AFW personnel already provide detailed turbulence forecasts for the Global Hawk high-altitude reconnaissance system.

The Forecasting System 21st Century (FS-21) program is the vehicle for providing necessary computer hardware and software throughout all levels of AFW (AFWA, OWSs, and CWTs). OPS-II is the backbone of OWS production, a hybrid system of databases, servers, and workstations encompassing the hardware and software necessary to produce and disseminate forecast products to CWTs. N-TFS provides garrison and deployed CWT personnel with the meteorological tools to manipulate and disseminate graphical and alphanumeric products

(satellite imagery, graphical forecast products, weather forecasts, advisories, briefings, observations, etc.) to Army and AF operational, C2, and support forces worldwide. N-TFS provides weather personnel the ability to use the same system in "peace and war," providing a "first in" and sustainment weather forecast capability to combat weather units across the globe. Additionally, N-TFS ingests data from AF and indigenous observing sources, which then are forwarded to OWSs/AFWA for further dissemination and incorporation into centrally produced models. Data from the N-TFS, combined with satellite imagery from the Small Tactical Terminal (STT), provide the essential capability required for deployed weather units to meet operational requirements (Figure 3-DOD-5). AFW is currently working toward a single workstation that integrates both the Army's Integrated Meteorological System (IMETS), the AF's N-TFS, and provides the interface capability for C2 systems.

The Joint Environmental Toolkit (JET) is expected to enhance warfighter awareness of the natural battlespace environment by ensuring accurate, timely, and consistent terrestrial and space weather data and impacts are available and accessible by appropriate personnel and processes. JET will fulfill this role by providing a single common forecaster interface to the virtual Joint METOC Database (JMDB) for use at all levels of the AFWWS support structure. JET integrates with Joint and coalition C4ISR/Mission Planning (MP) systems by enabling machine-to-machine exchange of METOC data and information to meet operational planning and execution requirements. Furthermore, JET enhances the accuracy and utility of terrestrial/space weather and oceanographic data, information, and operational impacts by enabling the forecaster and/or forecast process to incorporate Geographic Information System (GIS) capabilities (to include a standard high-resolution topographic database), forecasting rules of thumb, operational thresholds, and more into forecasts and weather impact products.

Contract award for JET is planned for July 2004 with award to two contractors for a 15-month fly-off. The down select to one contractor is projected for October 2005 with fielding of the first increment to begin in Spring 2006. Expected delivery of all JET capabilities is FY 2011.

Tactical Decision Aids (TDAs) provide warfighters an automated way to "visualize" environmental impacts on operations. These tools, which continue to be integrated into command and control systems and mission planning systems, include Target Acquisition Weapon Software (TAWS) and InfraRed Target Scene Simulation (IRTSS). All are modular programs developed by the Air Force Research Laboratory (AFRL) with additional assistance from the Navy's Space and Naval Warfare Systems Command, the Navy Research Laboratory (NRL), and the Army Research Laboratory (ARL). TAWS provides a joint mission-planning tool to combine platform, weapon, target, background, and weather impacts to depict three-dimensional target acquisition and lock-on range versus time. This includes pre-

Figure 3-DOD-5. 48th Combat Weather Team Forecaster, checks the satellite dish alignment on the small tactical terminal. This dish receives satellite pictures every 30 minutes from a geostationary earth orbiting satellite 22,000 miles above Europe (AFWA website).

diction of environmental impacts on night vision goggles and low light-level systems used by air, naval, and ground forces to execute nighttime operations, including search and rescue missions (Figure 3-DOD-6). IRTSS uses detailed terrain information and multispectral imagery with TAWS processing to generate forecast target scene images for mission rehearsal. The Joint Environmental Exploitation Segment (JEES) uses environmental data with TAWS modules to automatically generate mission-impact forecasts for large-scale planning efforts such as Air Tasking Order preparation. JEES, TAWS, Night Vision Goggles Operations Weather Software (NOWS), and IRTSS integrate environmental impacts into the mission execution forecasts for C2 and MP systems from 0-72 hours prior to mission execution. The TDA program continues to add weapons systems, targets, and other features at the request of users from each military service. During Operations IRAQI FREEDOM and ENDURING FREEDOM, the WarWeather program provided additional targets requested specifically for application with TAWS and IRTSS systems to support operations. Additional decision aids in development include a common rules-based decision aid (Army, Navy and Air Force participation) based on the Army Integrated Weather Effects Decision Aid (IWEDA) and Airborne Laser (ABL) Atmospheric Decision Aid (ADA) to support ABL development and operations. Developments in coordination include a common Radio Frequency (RF) system performance prediction capability based on Navy software.

The space weather branch produces tailored forecasts to model space weather impact to High Frequency (HF) and Ultra-HF satellite communications. These products leverage space weather expertise at AFWA for all theaters. A point-to-point communication forecast can be tailored to provide users the optimal HF frequencies to employ between two locations. Also, signal fades due to space weather on UHF SATCOM links provide valuable planning information to improve command and control functions.

Dissemination. AFW dissemination employs a variety of media to meet the needs of users worldwide. High-speed communications between large DOD and civilian processing centers facilitate sharing of data, high-resolution satellite imagery, and output from numerical weather prediction models. Additional circuits provide a subset of these data to OWSs.

Forecaster-developed products and gridded data sets are distributed from AFWA via the Communications Front-End Processor (CFEP) to base and post weather stations around the globe using dedicated circuits and the Internet. Alphanumeric data, including surface, upper-air, space weather, and pilot reports, are also collected and distributed via the Automated Weather Network (AWN), Very Small Aperture Terminal (VSAT) satellite communications system, and the DOD's Non-Secure Internet Protocol Router Network (NIPRNET). The AWN, consisting of sophisticated data collection, message creation, and dissemination software, is a global communications network used for alphanumeric terrestrial and space weather data. The AWN supports DOD as well as federal and foreign meteorological, space, and aviation centers.

DOD data is also received from DOD-operated HF radio receiver sites strategically positioned around the globe to intercept weather broadcasts. These broadcasts originate from nations that do not routinely make data available through World Meteorological Organization (WMO) channels.

AFWA receives alphanumeric weather data, parses it according to data type, eliminates duplicate reports from different sources, and creates specially tailored bulletins. Some of these bulletins are sent to the large processing centers to provide the input data for global, regional, and fine-scale forecast models. Other bulletins are redis-

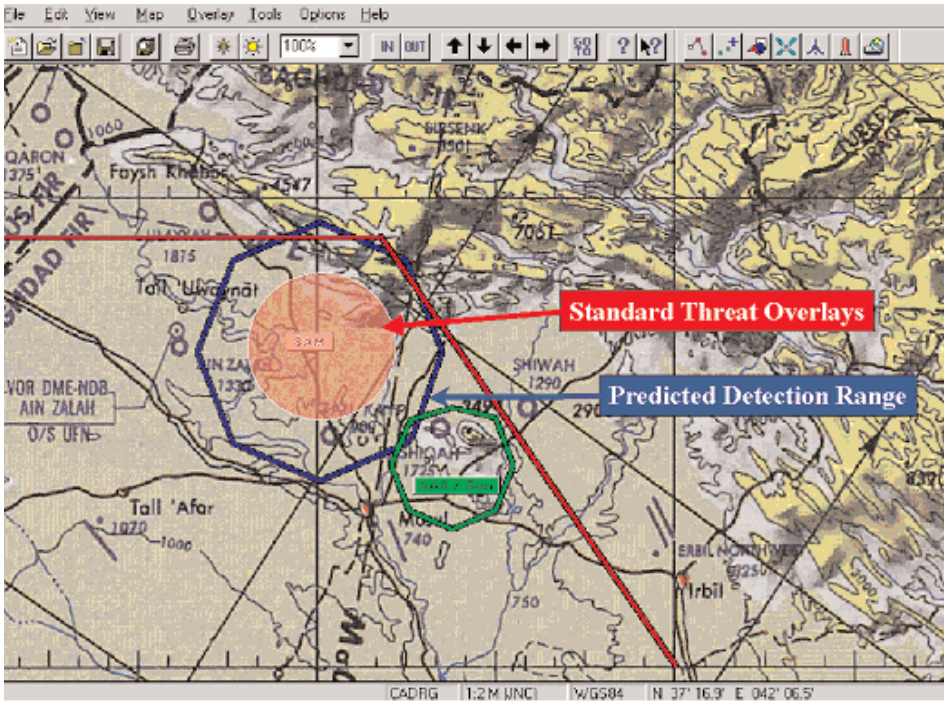

Figure 3-DOD-6. Target Acquisition Weapon Software (TAWS) integrate meteorological conditions and environmental parameters to enhance the mission planning process and increase aircrew situational awareness for mission execution.

tributed to end-users over dedicated circuits, NIPRNET, and satellite broadcast facilities.

AFW operates a website on the NIPRNET known as the Joint Air Force-Army Weather Information Network (JAAWIN). JAAWIN provides worldwide access to numerical model forecast graphics, satellite imagery, forecaster-in-the-loop (FITL) graphics, and text bulletins. Additional products are available to classified users via JAAWIN-Secret (JAAWIN-S) and JAAWIN-Sensitive Compartmented Information (JAAWIN-SCI).

Joint Weather Impacts System (JWIS) offers another means of making tailored weather information available to DOD users. JWIS provides a link to weather information from both AF and Navy sources for exploitation by command and control systems and applications. AFW successfully demonstrated JWIS during Joint Expeditionary Force Experiment 2000 and integrated an initial capability into the Combined Air Operations Center-Experimental in 2001.

Finally, AFW continued to enhance its presence on the AF Portal, an initial "one-stop gateway" capability to provide weather and other information to any AF user or activity. AFW will continue expanding its presence on the AF Portal in FY 2005.

Unique Requirements. A special aspect of the military weather mission is the need to provide decision assistance to commanders and resource managers as well as operational units. To fulfill this requirement, designated AFW personnel serve as part of the staff of operational AF, Army, and joint force units. In this capacity, AFW personnel identify all weather-sensitive areas of the operation, monitor the weather service provided in these areas, and provide expert advice to mitigate weather impacts on either training or combat operations. Products and data are tailored to the needs of weapon systems being developed or used; command and control systems; Army firing units; research, development and evaluation; testing, training and deployment of military forces; and contingency operations. This effort helps ensure that AF, Army, and joint force units fulfill their missions regardless of the weather and results in efficient use of weather resources by gearing them to specific requirements.

Figure 3-DOD-7. AF combat weather personnel, trained to support of Army operations, prepare to launch a pilot balloon to collect upper level winds.

Army weather requirements are completely integrated into the AF's overall mission concept (Figure 3-DOD-7). The Army trains and educates AF personnel on Army organizations, concepts of operations, and the weather sensitivities of Army operations and equipment. AFW units are aligned and integrated with the Army intelligence organization. Weather products are tailored to be pertinent to and directly usable by Army personnel and are integrated into Army C2 systems. The AF programs mobile and fixed meteorological equipment. AFW personnel currently serve with echelon above corps, corps, divisions, separate brigades, aviation brigades, armored cavalry regiments, ranger regiments, and Special Forces groups (as well as subordinate battalions deployed at forward operating bases). The AF normally provides observations at all command levels identified above; however, as the Army undergoes transformation to units of employment and units of action, AFW will transform its Army support organization appropriately. The Army Forward Area Limited Observing Program (FALOP) and the Army artillery meteorology (ARTYMET) program augment the AF observations in the tactical environment.

The AF provides meteorological and space weather products to the nation's space and missile programs including a wide range of weather observing services at the AF Eastern Range and the Kennedy Space Center (KSC). The AF also provides tailored forecasting for NASA's manned and unmanned launches and for commercial launches from KSC. The AF also provides specialized meteorological information to the AF Western Range at Vandenberg AFB, California, and the Pacific Missile Range, which includes Point Mugu and San Nicholas Island, California, and Barking Sands, Hawaii. In addition, the AF provides environmental information to the White Sands Missile Range, New

Figure 3-DOD-8. Solar optical and radio telescopes at Ramey, Puerto Rico and Learmonth, Australia (lower left).

Mexico, the Kwajalein Missile Range, Republic of the Marshall Islands, and other DOD research and test facilities.

The AF furnishes environmental information to DOD Special Strategic Programs, the President, Secretary of Defense, the National Military Command System, and the National Security Agency. Tailored environmental products are disseminated to these users worldwide.

The AF also provides agrometeorological output to the United States Department of Agriculture's Foreign Agricultural Service and other similar users. The output provided includes diagnostic soil hydrology and other meteorological output pertinent to crop growth and yield estimation as well as trafficability and rudimentary flooding estimations.

AFCCC provides climatic data and specialized products to the AF, Army, and other government agencies. Typical climatic information satisfies requirements for assessments of natural environmental effects on military plans, weapon systems, facilities, and intelligence activities. AFCCC collects, quality assures, and applies worldwide surface and upper air observations, satellite-derived soundings, numerical model output such as global gridded surface and upper air model data, a global three-dimensional cloud analysis (worldwide merged cloud analysis), a global analysis of snow cover, and other specialized environmental data sets. AFCCC produces standard climatic summaries of meteorological phenomena for points around the globe. Examples include the Operational Climatic Data Summary and the Wind Stratified Conditional Climatology. Analysts are also available to produce tailored products to meet specific requirements. AFCCC employs the Atmospheric Slant Path Analysis Model to produce vertical profiles for any point on earth for any time since 1985. Modeled climatologies are produced using the Advanced Climate Modeling and Environmental Simulations model. AFCCC is co-located with the National Climatic Data Center to facilitate cooperation and data exchange.

AF/XOO-W is the DOD Air and Space Natural Environment Modeling and Simulation Executive Agent (ASNE MSEA). The director executes this responsibility through the ASNE MSEA office, a division within AFCCC (AFCC/SM). The executive agent is responsible for ensuring modeling and simulation developers and users have the tools, infrastructure, and databases necessary to represent the air and space natural environment.

AFCCC/SM sponsors research and development and fields technology at AFCCC, the designated operational center providing tailored atmospheric data for modeling and simulation. In cooperation with the National Geophysical Data Center (NGDC) and the Defense Modeling and Simulation Office (DMSO), AFCCC/SM also sponsors ongoing research to develop a similar capability to provide tailored on-demand representations of the space environment.

SPACE ENVIRONMENTAL SERVICES

AFWA is the sole source of DOD space environmental information and partners with the NOAA SEC to meet the nation's military and civilian space weather needs. Many DOD systems are affected by space weather phenomena occurring in the near-Earth environment. Space weather impacts fall into three general categories: ionospheric effects on radars, GPS, and C4ISR systems; the effect of high-energy charged particles and radiation belt enhancements on the operation and serviceable lifetime of orbital platforms; and the effect of geomagnetic storming on C4ISR, radar, GPS accuracy, and electrical power generation. AFWA provides a suite of automated and manually tailored space weather products to operators susceptible to these impacts.

Sources of Space Environmental Information

A combination of ground- and space-based space weather data are available to forecasters providing space environmental situational awareness and tailored information for military operations.

Ground-based data provides highly accurate point source verification and specification of the near-Earth environment. AFWA operates the Solar Electro-optical Observing Network (SEON), a network of solar optical and radio telescopes at Sagamore Hill, Massachusetts; Holloman AFB, New Mexico; Palehua, Hawaii; San Vito, Italy; and Learmonth, Australia. These systems provide 24-hour observations of solar phenomena at optical and radio wavelengths (Figure 3-DOD-8). A worldwide (primarily Northern Hemisphere) network of ground-based ionosondes and other sensors provide ionospheric data. AFW manages 17 automated Digital Ionospheric Sounding Systems (DISS) to measure electron density profiles in the ionosphere. NASA's Jet Propulsion Laboratory (JPL) operates a complementary global network of sensors deriving ionospheric line-of-sight Total Electron Content (TEC) from GPS signals and provides this data to AFWA's Space WOC. In addition, the United States Geological Survey (USGS) operates a network of ground-based magnetometers, primarily in the Northern Hemisphere, which provide critical measurements of the geomagnetic field and its variances to the Space WOC. AFWA receives JPL and USGS data from the SEC.

Space-based data enables global coverage and theater-wide situational awareness of the near-earth environment. The GOES meteorological satellites provide real-time solar X-ray, charged energetic particle, and geomagnetic data made available through the SEC. The Solar X-Ray Imager (SXI), which became operational 30 January 2003, aboard GOES-12, monitors solar emissions in the extreme ultraviolet (EUV) and X-ray portions of the solar spectrum and provides near real-time display at AFWA and the SEC. DMSP, NOAA, and other DOD geostationary satellites provide charged energetic particle data in low-Earth and geosynchronous orbits. Additionally, AFW leverages space-based data from NASA and other agencies. For example, NASA's Advanced Composition Explorer satellite provides real-time solar wind data critical for forecasting geomagnetic disturbances and their impact to warfighter communications.

Space weather models transform observational data into useful specification and forecasts enabling leaders,

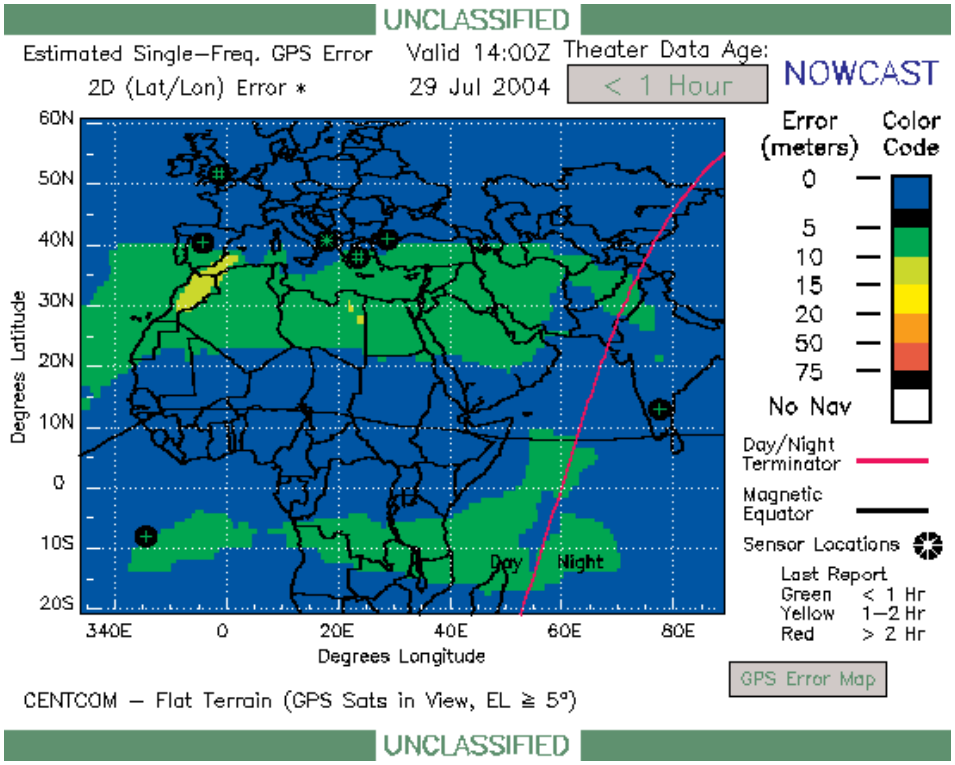

Figure 3-DOD-9. Single-Frequency GPS Receiver Error Map (visualized by HQ AFWA)

planners, and operators to achieve asymmetric advantage through information superiority and improved space situational awareness. AFWA uses a suite of state-of-the-art space weather models to specify current solar and global characteristics, extrapolate space weather phenomenon to areas of the globe where observations are not currently available, and to forecast future conditions. These models use available observations and include both climatology-based and physics-based algorithms. Examples of model output informational products include the Single-Frequency GPS Receiver Error maps (Figure 3-DOD-9), UHF Satellite Communication Scintillation maps (Figure 3-DOD-10), HF Illumination maps (Figure 3-DOD-11), and Radar Auroral Clutter maps. These products assist warfighters in determining and mitigating space weather impacts to their systems as well as in exploiting enemy space weather susceptibilities for asymmetrical advantage. More detailed descriptions of both the available observations and current models can be found in Chapter 2 of the *National Space Weather Program Implementation Plan*, Second Edition, available from the Office of the Federal Coordinator for Meteorology.

Mainstreaming Space

AFW continues efforts to "mainstream" space weather for both providers and users. DOD's increasing reliance on systems affected by space weather, continuing expansion of operations into space, and the AF's designation as executive agent for space indicates space weather will become increasingly important. Once fully mainstreamed, weather information users at all levels should think of space weather as quickly as they do terrestrial weather. The AFW goal is to create a seamless, real-time depiction of the entire natural environment from the mud to the sun by planning, programming, and budgeting for space weather initiatives. AFW is taking steps to standardize space weather operations, improve space weather training for both providers and users, integrate both space and terrestrial environmental situational awareness into users' decision architectures, and improve interaction with end users. AFW recognizes the need to better collect reports of space weather impacts on operations in order to demonstrate the value and utility of total environmental situational awareness, including space weather. To this end, AFW is reaching out to non-traditional users such as communicators, aeromedical services, and airlifters to solicit their assistance in collecting space weather impacts.

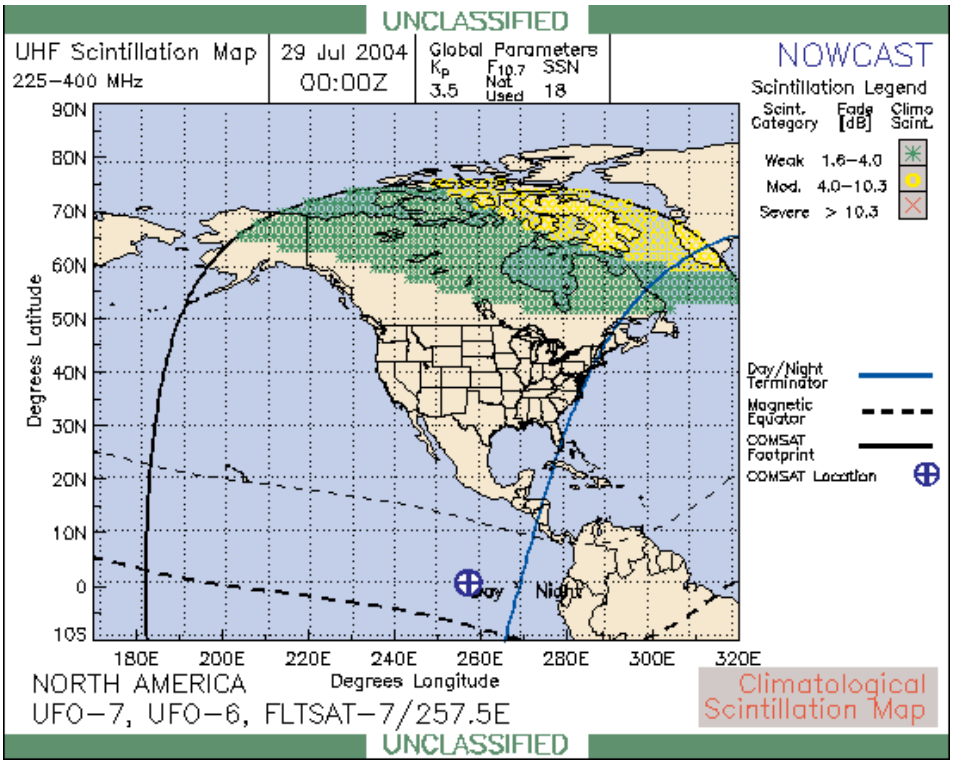

Figure 3-DOD-10. UHF Satellite Communications Scintillation Map (visualization by HQ AFWA)

RESEARCH INITIATIVES

The overarching objective of the AF meteorological and space environmental research and development (R&D) program is to provide capability designers, operational weather personnel, and weather information users with the technology and tools to gain and maintain the advantage over a potential adversary. Documented R&D requirements in the atmospheric sciences are articulated in the AFW Mission Support Plan and in the Mission Area Plans of the AF major commands. Space environment R&D is targeted to meet the DOD's space weather requirements as summarized in the National Security Space Architect's Space Weather Architecture Study as well as the National Space Weather Program Implementation Plan, Second Edition. AFW also strives toward improvements through cooperative research and development agreements with for-profit companies.

In meteorological R&D, the AF is improving cloud depiction and forecasting (CDF) techniques by doubling the resolution, integrating geosynchronous METSATs into the cloud analysis, using a new cloud interpretation scheme, and blending numerical weather prediction with forecast cloud advection techniques. The AF has transitioned key advances in tactical decision aids into operations, permitting improved forecasting of electro-optical system performance and generation of cloud and target scene visualizations for training, system develop-

ment, and mission rehearsal. In addition to internal efforts, AFW will continue to rely on collaboration and leveraging of efforts with other federal meteorological agencies, research labs, and universities to further improve CDF system performance and meet other research needs.

Mesoscale Modeling for Air Force and Army Operations

Efforts have continued for combining the MM5 and Land Surface Model (LSM) for use by AF and Army operations. The LSM analyzes the current state of the land surface to provide information to both DOD and civilian agencies, and through coupling with MM5, will improve forecasting performance in the low levels of the atmosphere. This allows AFW to provide better forecasts for low-level aircraft operations, the dispersion of aerosol contaminants, and the employment of precision-guided munitions. It also allows for assessment of trafficability for ground forces. The advances achieved in the LSM are also being carried over into Weather Research and Forecast (WRF) model development, another area of AFWA participation in research. AFWA is closely collaborating with the National Center for Atmospheric Research (NCAR), NOAA's NCEP, NOAA's Forecast Systems Laboratory (FSL), the University of Oklahoma's Center for the Analysis and Prediction of Storms, and others in WRF development. WRF is the next generation community model expected to replace MM5. AFWA is preparing to fully implement WRF operationally in 2005 and will continue with sponsorship and funding of development at NCAR and FSL, test and evaluation of real-time runs of the WRF prototype, and will lead the LSM Working Group while participating in others.

Through a joint Air Force-Navy effort, AFWA and FNMOC were awarded a $3 million grant from the DOD High Performance Computing

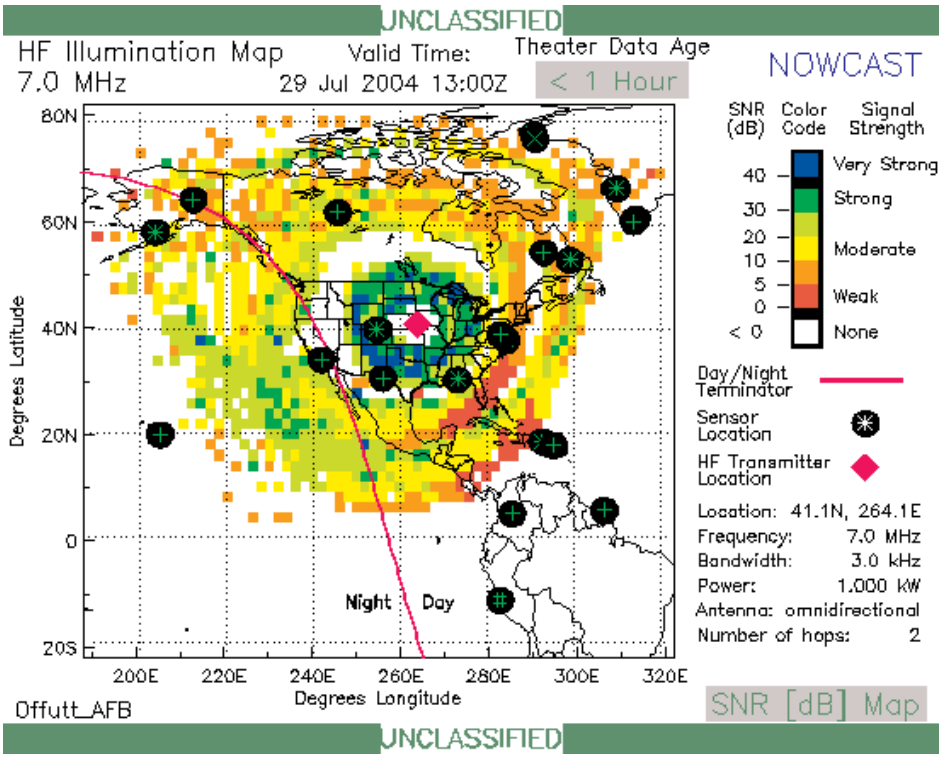

Figure 3-DOD-11. HF Illumination Map (visualized by HQ AFWA).

Modernization Office in 2004 to establish an operational test and evaluation center for the WRF modeling framework. Additionally, each organization gains status as a DOD High Performance Computing Distributed Center. The WRF Operational Test Center (OTC) will greatly enhance DOD's ability to efficiently incorporate state-of-the-science modeling technologies into operations. The end result will be never-before-seen predictive accuracy of fine-scale weather features crucial to DOD operations. The plan is to install a cutting-edge IBM supercomputer suite at each weather center split into two identical subsystems. The distributed WRF OTC subsystems will be virtually integrated using high-speed communications networks, thus allowing operational simulations with real-time weather data from each center. After rigorous test and evaluation, the specialized WRF configurations that perform optimally for DOD and service-unique mission needs will be implemented at AFWA and FNMOC.

Atmospheric Optical Turbulence

Electro-optical (EO) systems are adversely affected by optical distortions caused by thermal or refractive turbulence. As the sophistication of current and next-generation military systems grows, the requirement for more detailed knowledge of fine-scale (meters or less) atmospheric behavior also grows. The Airborne Laser (ABL) program is one such capability whose performance is highly dependent on the variations of the meteorological conditions that produce optical turbulence. The AF program in atmospheric optical turbulence measurements and modeling seeks to address these needs. Researchers used a balloon-borne turbulence sensor mated to a standard radiosonde to obtain measurements, producing data and empirical models that are the basis for ABL system specification. Balloon-borne measurements were made in conjunction with airborne stellar scintillometer measurements to understand the relation between atmospheric structure and path-integrated optical effects. The turbulent scalar spectrum was also

sampled using balloon-borne high-bandwidth sensors. As part of an international program, aircraft measurements of temperature and velocity turbulence have been made in different locales worldwide. Horizontal measurements by the aircraft augment the vertical profiling by balloons to assist in the development of the detailed knowledge required by new EO systems.

Atmospheric Optical Opacity

Air-and space-borne reconnaissance systems are adversely affected by optical distortions caused by clouds, fog, haze, and other airborne particles. As the sophistication of current and next-generation military systems grows, the requirement for more detailed knowledge of smaller scale (meters or less) atmospheric behavior also grows. The AF's Cloud Depiction and Forecast System II (CDFS-II) program seeks to address these needs (Figure 3-DOD-12).

Radar Analysis using Digital Terrain Elevation Data (DTED), MM5 data, and Advanced Propagation Model (APM) Prediction Software (RADMAPS)

Through the University Partnering for Operational Support (UPOS) program, Johns Hopkins University Applied Physics Laboratory (JHUAPL) has developed RADMAPS, an application to assess and forecast anomalous propagation for ground-, airborne-, and sea-based radars. RADMAPS uses DTED from the National Geospatial Agency (formerly known as the National Imaging and Mapping Agency) along with a newly developed and unique MM5 capability to forecast radar refractivity in the lower atmosphere, and the APM (a model developed by Space and Naval Warfare Systems Command) to predict atmospheric and terrain effects on radar performance.

United States Weather Research Program (USWRP)

USWRP's mission is to accelerate forecast improvements of high-impact

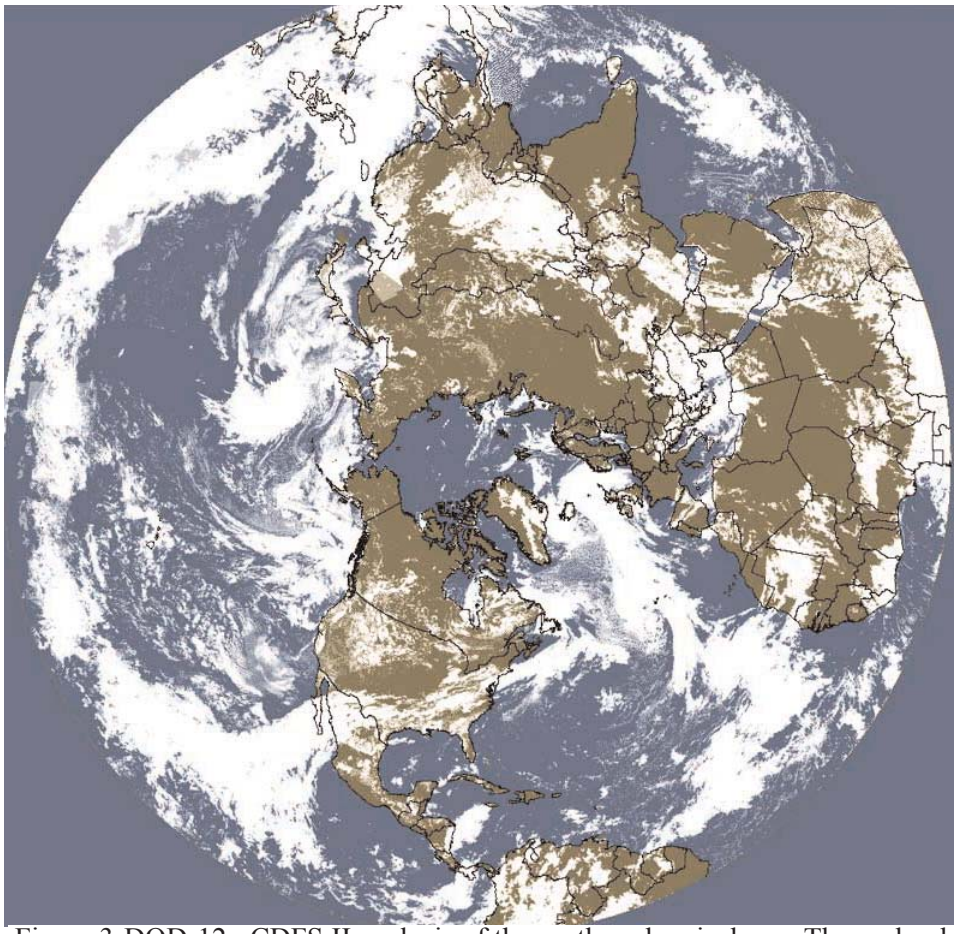

Figure 3-DOD-12. CDFS II analysis of the northern hemisphere. These cloud products provide mission planners a complete picture of the battlespace from ground to upper atmosphere.

weather and facilitate full use of advanced weather information. AFW first entered into discussions with USWRP in 2001 to explore expanded participation in the program. The program currently focuses on land-falling hurricanes, heavy precipitation, and socio-economic impacts. AFW is eager to leverage future efforts in the areas of observing and assimilation strategies in data-sparse regions and urban forecast issues to increase warfighters' abilities to anticipate and exploit the weather. AFW is already committed to the USWRP-affiliated community development of the WRF model and will continue its USWRP involvement during the coming fiscal year.

University Partnering for Operational Support (UPOS)

AFW continued to collaborate through the UPOS program with JHUAPL, the University of Alaska at Fairbanks Geophysical Institute, and ARL. UPOS provides a link between university research and the DOD operational community and is currently focused on near-term forecasts of ground, tropospheric, ionospheric, magnetospheric, and solar weather. The goals of UPOS are to provide an alternate path for rapid transition of the best-applied research ideas to the warfighter and to raise awareness of DOD operational needs within the academic community. The partnership delivers prototype operational products to AF and Army sponsors. The UPOS Steering Committee, which includes the AF Director of Weather, meets semiannually to review progress and approve new projects. UPOS includes warfighter exercise support to demonstrate utility of products through web-based, non-operational access as

well as collecting direct user feedback for faster updates of the prototype systems. Some examples of UPOS tropospheric weather work include fine-scale polar numerical weather prediction, operational volcanic plume forecasting, and electromagnetic propagation forecast maps generated from MM5 output. Examples of space science work include high frequency radar and communication propagation to predict the area a transmitter can illuminate, forecasting coronal mass ejections, and improving determination of solar events that will cause militarily significant space weather effects on and near Earth.

Air Force Research Laboratory (AFRL)

In other space weather research, AFRL programs focus on ionospheric impacts to radio frequency systems, space particle specification and forecast, solar disturbance prediction, and neutral density effects on Low-Earth Orbit (LEO) spacecraft. Working closely with the DMSP System Program Office (SPO) at the Space and Missile Center (SMC) under a Memorandum of Agreement, AFRL supports the development and upgrading of operational space weather sensors, models, and software products to include: space environment sensors on the DMSP spacecraft; state-of-the-art ground-based scintillation detectors; total electron content sensors; Digital Ionospheric Sounding System (DISS), the Solar Observing Optical Network; and the Operationalized Space Environment Network Display suite of web-based products. AFRL also conducts customer-supported R&D for NPOESS, the Defense Modeling and Simulation Office (DMSO), the National Reconnaissance Office (NRO), the Ballistic Missile Defense Office (BMDO), the DOD High Performance Computing Modernization Office, and NASA. This program continues in 2004 to build improvements for future operational implementation.

In addition to the AFRL research portfolio, AFW collaborates with others in the space weather community to develop new techniques, models, and systems for transition to operational applications. These include the Community Coordinated Modeling Center, the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC), and the previously mentioned UPOS.

In conclusion, through a continuous process of review and definition, the AF documents its requirements for research aimed ultimately at providing timely, accurate, and relevant weather information to the warfighter today and in the future. In meteorological R&D, AFW is committed to continued development of the WRF model and collaboration with others to the benefit of the warfighter and the nation. Space weather research will continue with a strong program in 2005 at the AFRL, as well as in leveraged programs such as UPOS, to facilitate expediting needed capabilities to operations at minimum expense.

PROGRAM OVERVIEW

The United States Navy has the unique military requirement to assess meteorological and oceanographic (METOC) impacts on naval, joint, and combined operations. METOC support begins by measuring the battlespace physical environment and culminates with safe, effective weapons systems and sensor employment. The perspective is global, and historically focuses on areas outside of the contiguous 48 states, but the emphasis is on wherever the Fleet goes and includes force protection within the coastal waters of the United States Developing METOC forecasts and determining potential effects on platform, sensor and weapons systems require:

- collection of METOC data through tactical and dedicated sensors (including satellites);
- fusion and analysis of atmospheric and oceanographic phenomena; and
- use of meteorological and oceanographic information in tactical decision aids and mission planning systems.

Two major Navy Meteorology and Oceanography (METOC) staff realignments occurred in 2003. The Office of the Oceanographer of the Navy, formerly the Chief of Naval Operations (CNO) N096, was realigned under CNO N6/7, Warfare Requirements and Programs, in December 2003 and is now CNO N61 (Director, Space, Information Warfare, Command and Control/Oceanographer of the Navy). The Commander, Naval Meteorology and Oceanography Command (CNMOC) was also realigned under Commander, Fleet Forces Command (CFFC) in October 2003. While operational requirements are coordinated through CFFC, it is the Chief of Naval Operations, through the Oceanographer of the Navy, who continues to sponsor operational Navy METOC support services and related research and development (R&D). The Navy METOC organization provides meteorological support services for Navy and joint forces, meteorological products to the uniformed services and other Government agencies, and oceanographic support to all elements of DOD. The Oceanographer of the Navy sponsors programs in four closely related disciplines to provide worldwide, comprehensive, integrated weather and ocean support - meteorology, oceanography, geospatial information and services, and precise time and astrometry. All are used to protect ships, aircraft, fighting forces, and shore establishments from adverse ocean and weather conditions, and to provide a decisive tactical or strategic edge by exploiting the physical environment.

Research and development is conducted by warfare centers, laboratories, and systems commands, through sponsorship by the Chief of Naval Research and the Oceanographer of the Navy. To ensure that all research and development supported by the Oceanographer is in direct support of the Naval Mission as established by formal Navy Doctrine, the Oceanographer has developed and implemented a comprehensive framework to transition research to operations. The Naval Research Laboratory (NRL) and the Program Executive Office (PEO), C4I and Space are the primary activities that manage naval research and transition to operations, and are supplemented by various universities, industry partners, and organizations under Navy contract. NRL detachments are collocated with the Fleet Numerical Meteorology and Oceanography Center in Monterey, California and with the Naval Oceanographic Office at Stennis Space Center, Mississippi. The PEO C4I and Space Program Office (PMW-150) is Navy's single program manager for METOC system development and acquisition (Figure 3-DOD-13).

Figure 3-DOD-13. At sea aboard USS ABRAHAM LINCOLN (CVN 72) -- Lightning fills the horizon, and lights up the flight deck and Carrier Air Wing Fourteen (CVW-14) aircraft parked on the ship's forward elevator and bow. (United States Navy Photo)

METEOROLOGICAL SERVICES

United States Navy

Operational support within the Navy is provided by elements of the Naval Meteorology and Oceanography Command (NAVMETOCCOM). Navy METOC activities are involved in worldwide collection of observations ashore, afloat and through remote sensors, and in the assimilation and processing of these observations on a global basis to support analysis and forecasting throughout the world.

The Fleet Numerical Meteorology and Oceanography Center (FLENUMMETOCCEN), in Monterey, California, provides global, regional, and tactical observations, analyses, and coupled air-ocean forecasts. Environmental data is acquired through links with DOD and NOAA conventional and remotely sensed data distribution systems. By agreement between Navy and Air Force, FLENUMMETOCCEN is the primary DOD global numerical weather prediction center, running the Navy Operational Global Atmospheric Prediction System (NOGAPS), developed by the Naval Research Laboratory's Marine Meteorology Division, also in Monterey. NOGAPS provides global atmospheric predictions and drives a variety of ocean models, including the global Wave Watch III ocean wave model run at FLENUMMETOCCEN. FLENUMMETOCCEN and the Naval Research Laboratory, Monterey are also participants in the development of the Weather Research and Forecasting (WRF) model initiative with the other federal Agencies.

In near-shore regions, the small-scale interactions between the atmosphere, underlying ocean, and nearby land make it necessary to analyze and predict the battlespace environment with higher resolution and improved physics. In addition to the global product suite, FLENUMMETOCCEN is uniquely capable of providing high-resolution coupled air-ocean products on short notice for any location in support of global contingency military and humanitarian operations. Navy's Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS) is an operational tactical system featuring data quality control algorithms; nested, non-hydrostatic physics; explicit moisture physics; aerosols; and improved data assimilation. Using lateral boundary conditions provided by NOGAPS, COAMPS provides a high-resolution, re-locatable, meteorological and oceanographic prediction capability to support joint littoral operations. COAMPS is routinely run for Europe, Southwest Asia, Western Pacific, Central America, Western Atlantic, the Continental United States, and the Eastern Pacific. COAMPS is frequently run in other areas around the world as requirements dictate.

NOGAPS and COAMPS forecast products are distributed via various communications systems including the Internet, either directly to Fleet customers, or through the Navy regional METOC centers. The regional METOC centers develop value-added products and services tailored to specific operational requirements. As a complement to numerical forecast products, FLENUMMETOCCEN provides atmospheric and oceanographic observations, satellite products, data extracts, and data for tactical decision aids. Additionally, FLENUMMETOCCEN is the designated National "Core Processing Center" for remotely sensed microwave products under the Air Force/Navy/NOAA Shared Satellite Processing Agreement. The FLENUMMETOCCEN web site for information is *https://www.fnmoc.navy.mil*.

Since atmospheric conditions are inherently coupled to oceanographic conditions, the Navy's program in meteorology is closely linked with oceanography, which is the focus of the Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, Mississippi. NAVOCEANO's primary responsibilities include the collection, processing, and distribution of oceanographic, hydrographic, and other geophysical data and products. NAVOCEANO disseminates products from the world's first operational global layered ocean model - Naval Research Laboratory (NRL) Layered Ocean Model (NLOM). NAVOCEANO is the Navy's primary processing facility for NOAA polar-orbiting satellite data and is the National "Core Processing Center" for satellite-derived sea-surface temperature measurements, providing the global sea surface temperature data critically important to successfully running NOGAPS and COAMPS. Additionally, NAVOCEANO is a DOD Major Shared Resource Center, enabling creation of the latest research and development models on the most modern scaleable, supercomputing architecture and facilitating transition from R&D to operational use. The NAVOCEANO web site for information is *https://www.navo.navy.mil*.

Tailored Theater and Regional Support

Theater and regional support are provided to forces ashore and afloat through six regional centers delivering METOC services within their broad areas of responsibility (AORs). These centers tailor services to theater requirements, and manage and prioritize dissemination of numerical products from FLENUMMETOCCEN and NAVOCEANO. Special products needed to meet requirements of Joint Force Commanders are also generated by the regional centers. Additionally, the Joint Typhoon Warning Center (JTWC) (operated by Navy and Air Force) is co-located with the Naval Pacific Meteorology and Oceanography Center in Pearl Harbor, Hawaii. Examples of METOC products generated at regional centers include high winds and seas warnings for the world's oceans, tailored forecast support for Navy, Coast Guard and

Figure 3-DOD-14. The guided missile destroyer USS COLE (DDG 67) encounters heavy seas while transiting across the Atlantic Ocean. (United States Navy Photo)

NOAA ships at sea, and ship routing services for ocean transits (Figure 3-DOD-14).

The Naval Ice Center (NAVICECEN), located in Suitland, MD, provides tailored ice forecasts and analyses to DOD. The Navy (through NAVICECEN), NOAA, and the United States Coast Guard, jointly operate the National Ice Center (NIC). The NIC provides ice analyses and forecasts for the Arctic and Antarctic regions, coastal United States waters, and the Great Lakes to civilian and military activities.

Local and Aviation Support

NAVMETOCCOM Facilities at Whidbey Island, Washington, Naples, Italy and Jacksonville, Florida, provide aviation forecast services as well as Fleet Operating Area (OPAREA) and local forecasts and warnings for aircraft, ships, submarines and naval bases and staffs. Additionally, there are 28 NAVMETOCCOM detachments worldwide. Though the detachments are primarily situated at Naval Air Stations for aviation safety of flight forecasting, several are located at Naval Stations in support of seagoing units. The detachments provide METOC forecasting and warning services to DOD and allied units within their local and functional areas of responsibility. Facilities and detachments within the continental United States use numerical products from both FLENUMMETOCCEN and NOAA's National Centers for Environmental Prediction (NCEP). Overseas Detachments and Facilities use FLENUMMETOCCEN numerical weather products, in addition to USAF and foreign METOC products. Additionally, FLENUMMETOCCEN provides aircraft routing services for military (primarily Navy) aircraft on demand.

Over the next few years the Navy's concept of operations for CONUS aviation weather support will shift from one of mainly local onsite air station support to netcentric weather support provided from regional aviation hubs at Norfolk, Virginia and San Diego, California.

One detachment, at the National Climatic Data Center, Asheville, NC, coordinates the Navy's Climatological Program as part of the Federal Climate Complex.

On-Scene Support

The Navy's permanent afloat METOC assets are their OA Divisions, embarked aboard aircraft carriers, major amphibious ships and command ships. The OA division's primary objectives are safety of ships, aircraft and embarked personnel, optimum tactical and planning support to on-board warfare commanders, and tailored on-scene products and services for the assigned task force/group and Allied units in joint, combined, or coalition military and humanitarian operations (Figure 3-DOD-15).

Deployable Mobile Environmental Teams (METs) are the primary source of on-scene Navy METOC support for other forces afloat and forces deployed ashore in remote operation areas. These teams provide short-term, on-scene services to DOD activities without organic METOC personnel, other government agencies, and elements of the armed forces of Allied nations during combined exercises or operations. METOC products and services provided by these METS are tailored to each unit's requirements, and include tactical METOC information and forecasts for operations, weapon and sensor system employment and tactical decision-making, and climatological information for long-range planning.

Over the next few years Navy anticipates merging the OA Division and MET personnel for manpower efficiency in our tactical support infrastructure.

United States Marine Corps (USMC)

The mission of the Marine Corps METOC Service is to provide meteorological, oceanographic, and space environmental information, products, and services required to support Marine Corps operations and other military operations. The Marine Corps METOC support infrastructure is designed to readily deploy and operate

in austere expeditionary environments. It is capable of providing sustained, comprehensive, and relevant METOC support to all elements of a Marine Air Ground Task Force (MAGTF), as well as bases and stations of the supporting establishment.

Organization

The Deputy Commandant for Aviation, Headquarters, United States Marine Corps (Code ASL-37) is the cognizant office for Marine Corps METOC support and requirements. The Marine Corps METOC organization consists of two operational chains-of-command, one for supporting establishment METOC units and the other for the Fleet Marine Force (FMF).

Supporting establishment METOC units are located worldwide at Marine Corp Air Stations (MCAS) and Facilities (MCAF). These activities are manned and equipped to provide direct aviation METOC support and services to host and tenant units at nine major air stations in the continental United States, one in Hawaii, and two in Japan.

Within the FMF, Marines deploy and employ as scalable, tailorable, combined-arms teams known as Marine Air Ground Task Forces. There are three sizes of MAGTFs. From smallest to largest, they are: Marine Expeditionary Unit (MEU), Marine Expeditionary Brigade (MEB), and Marine Expeditionary Force (MEF). Additionally, Special Purpose MAGTFs (SPMAGTFs) may be formed to support operationally unique situations and/or requirements. All MAGTFs, regardless of size, share four organizational elements that vary in size and composition according to the mission: Command Element (CE), Ground Combat Element (GCE), Aviation Combat Element (ACE), and Combat Service Support Element (CSSE).

FMF METOC activities are organized, trained, and equipped to provide tailored support, products, and services to all combat elements of the MAGTF. METOC support is focused towards impacts on Expeditionary Maneuver Warfare (EMW) operations, particularly Operational Maneuver from the Sea (OMFTS). FMF METOC activities are fully interoperable within joint force operations as part of a service or functional component command. When directed to stand-up as part of a Joint Task Force Headquarters (JTF HQ), they are capable of planning, coordinating, and leading joint METOC operations. Marine METOC forces can rapidly transition from precrisis state to full operational capability in a distant theater to provide on-scene support to MAGTF, combined, joint, allied, and coalition operations and other military operations as may be directed (Figure 3-DOD-16).

Figure 3-DOD-15. . Fleet Logistics Support Squadron Four Zero (VRC-40) maintenance personnel prepare to move one of their C-2A Greyhound aircraft, currently assigned to USS GEORGE WASHINGTON (CVN 73), into the protection of a hangar as a large snow storm hits Crete, Greece.
(United States Navy Photo)

FMF METOC assets are permanently assigned to Marine Expeditionary Force Headquarters (MEF HQ), Intelligence Battalions, Marine Wing Support Groups (MWSGs), and Marine Wing Support Squadrons (MWSSs). There are three Marine Expeditionary Forces strategically positioned for global response. I MEF, based in southern California and III MEF, forward based in Okinawa, mainland Japan, and Hawaii fall under the control of the Commander, Marine Forces Pacific. II MEF, located at bases in North and South Carolina, falls under the command of the Commander, Marine Forces Atlantic. MEF METOC personnel serve as special staff to the Commanding General (CG) and are under the direction and cognizance of the G-2 (Intelligence) Division.

The three Intelligence Battalions in the Marine Corps are co-located with respective Marine Expeditionary Force Headquarters. These battalions directly support the MEF G-2 and serve as MAGTF intelligence centers during operations. METOC is a vital part of the intelligence estimate and is an essential element that supports the Marine Corps Rapid Response Planning Process. METOC personnel assigned to these commands provide expertise, products, and services that directly support the Intelligence

Preparation of the Battlespace (IPB) process by helping intelligence analysts to effectively evaluate, integrate, and synchronize METOC effects for both enemy and friendly courses of action.

Marine Aircraft Wings (MAWs) conduct the complete range of air operations in support of the MEF, to include anti-air warfare, offensive air support, assault support, aerial reconnaissance, electronic warfare, and control of aircraft and missiles. The MAW serves as the principle headquarters for the ACE. Most of the MAGTF's METOC support assets reside within the MAW, specifically at the MWSG and its subordinate MWSSs. These assets are organized, structured, and capable of supporting a variety of MAGTF and ACE-specific operations as defined by the size, scope, and mission requirements. Dedicated METOC support is available for all MAGTF elements from within the MAW/ACE.

METOC Support Capabilities

Meteorological Mobile Facility-Replacement (MetMF(R)). The highest level of METOC support to the MAGTF and ACE-specific operations is the deployment of the MetMF(R). The MetMF(R) provides a METOC support capability similar to that found in garrison METOC facilities, is normally deployed as part of MWSS to a Forward Operating Base (FOB), and is the only realistic option for large-scale MAGTF operations. Once established ashore, the MWSS may detach small METOC support teams with portable ancillary equipment to a forward base in support of ACE units that are separated from the main airbase. This redeployment also provides the MetMF(R) with a forward data collection capability that significantly enhances METOC situational awareness and overall support efforts to the entire MAGTF. With appropriate service personnel augmentation, the MetMF(R) is also capable of serving as host for an in-theater Joint METOC Forecasting Unit (JMFU) during joint operations and exercises.

Figure 3-DOD-16. Rain and heavy winds from Hurricane Isabel pound the beach at Naval Station Norfolk, as the storm moves inland. Hurricane Isabel, which cost the Navy nearly $130 million in damage in the Mid-Atlantic region of the U.S., made landfall as a Category 2 storm near Cape Hatteras, N.C., approximately 100 miles south of Norfolk. (United States Navy Photo)

METOC Support Team (MST). MSTs are task organized and equipped to provide a limited level of METOC support to combat elements other than the ACE (e.g. CE, GCE, and CSSE) and can be assigned to support MEU operations. It is capable of rapidly deploying as part of a first-in level of METOC support response to a crisis and can be easily integrated into an Air Contingency MAGTF (ACM). Additionally, the MST can be assigned to augment a JMFU during joint operations (Figure 3-DOD-17).

Each MWSS within the MAW is structured and organized to provide one MST that consist of one METOC officer, two forecasters, and two observers. When deployed, the MST will normally be assigned to the G/S-2 (Intelligence) division/section of the supported combat element or MEU. The MST deploys with rugged, ancillary environmental collection and data processing equipment. During operations they organically collect METOC products, data, and information from the nearest deployed MetMF(R), Navy METOC OA Division afloat, host nation or other METOC support organizations and agencies to satisfy METOC information requirements.

Specialized METOC Support

The Marine Corps' Chemical Biological Incident Response Force (CBIRF) was established in 1996 as a result of Presidential Decision Directive (PDD) 39 to manage the consequences of Nuclear, Biological, and Chemical (NBC) materials or weapons used by terrorists. This national level asset is part of the re-activated 4th Marine Expeditionary Brigade - Anti-Terrorism (MEB-AT) located at Indian Head, Maryland. It is comprised of specially trained and equipped Navy, Marine, and civilian personnel who can rapidly be forward deployed and/or respond to a credible threat of a Chemical, Biological, Radiological, Nuclear, or High Yield Explosive (CBRNE) incident in order to assist local, state, or federal agencies and designated Unified Combatant Commanders in the conduct of consequence management operations.

Within the S-2 (Intelligence) section, a permanently assigned METOC forecaster provides specialized NBC dispersion forecast products and services that aid mission accomplishment of this organization.

METOC Support Doctrine

Marine Corps Warfighting Publication (MCWP) 3-35.7, MAGTF Meteorological and Oceanographic Support, provides more detailed information about the Marine Corps METOC Service. An electronic copy is available for viewing and downloading from the Marine Corps Combat Development Command (MCCDC), Doctrine Division web site at *https://www.doctrine.quantico.usmc.mil/*.

MAJOR METOC SYSTEMS

The capability to provide near real-time global, regional, and local METOC services to the Navy and Marine Corps team requires a robust and evolving set of leading edge technological tools. These tools are embodied in the following systems:

Primary Oceanographic Prediction System (POPS) II Upgrade (POPS II U)

The POPS II U operates complex computer-based models of the world's ocean and atmosphere, and disseminates METOC forecasts, charts, imagery, and operational data sets to support deployed Navy and DOD forces worldwide. This data is essential to the safety of personnel and to the operational effectiveness of the Navy's operational platforms, sensors, and weapons; including cruise and ballistic missiles, ships, aircraft, radar, and sonar. POPS II U prediction models must provide horizontal resolutions of 1-5 kilometers, in near real-time, for use in on-scene tactical decision aids and systems. Thus, POPS II U provides tailored and timely predictions of METOC conditions to assist in optimizing the tactical deployment of United States sensor and weapon systems.

POPS II U produces and provides critical, classified and unclassified atmospheric and oceanographic guidance to Navy and DOD activities worldwide on a demanding and responsive, 24-hour/7-day schedule. POPS II U is responsible for all FNMOC operations, including the supercomputing, communications (including receipt of tens of thousands of observations and transmission of hundreds of model products), database management, data assimilation and distribution, and systems control/monitoring. It is the engine that runs all of the Navy's global/regional/ tactical atmospheric, oceanographic, wave, ice, and tropical cyclone models. POPS II U is a national system that assimilates both classified and unclassified data. Classified observations from the battlespace provide a rich source of data that improves the initial METOC analyses and ultimately the METOC predictions. The capability to process this type of highly sensitive information in a wartime scenario is unique to POPS II U. POPS II U also produces and disseminates classified and unclassified global/regional atmospheric guidance that is used by:

- Navy for global ocean, regional and tactical ocean/atmosphere/ wave/ice/tropical cyclone models and distributed tactical forecast systems,
- Air Force for regional atmospheric models, cloud prediction systems, and strategic decision aids as specified via the Navy/Air Force agreement,
- Joint Forces Command, Defense Threat Reduction Agency and Lawrence Livermore National Laboratory for Weapons of Mass Destruction (WMD) decision aids and aid in contingency planning,
- Central Intelligence Agency (CIA) for aid in contingency planning,
- National Weather Service (NWS) weather supercomputer back-up,
- Strategic Command for ballistic missile support,
- Presidential Support Unit for aid in contingency planning.

Figure 3-DOD-17. An M-1A1 Abrams tank crew from Company B, 1st Tank Battalion, 1st Marine Division settles in for the evening after a recent patrol. The 70-ton tank stands a vigil on the side of the road to guard against any terrorist activity on the road (United States Marine Corps Photo).

Support to the operating forces is provided principally through six geographically dispersed regional commands via direct connectivity through DOD circuits. The primary source of data to these regional centers is POPS II U. Additionally, thousands of DOD users receive their product support directly from POPS II U via the creation of web enabled tactical applications.

POPS II U is composed of a number of different high-performance computer systems, including a 128 processor Origin 3800, two 12 processor Origin 3400 file servers, and a 512 processor

Origin 3800. POPS II U forms the primary basis of METOC support throughout DOD. This capability includes state-of-the-art decoders, data management systems, quality control algorithms, and data assimilation software for all types of METOC data from all available sensors. These data will support state-of-the-art numerical weather, ocean, chemical/biological dispersion and acoustic models, run in multiple nested fashion from global scale models at resolutions of tens of kilometers to battlegroup/battlefield models at resolutions of a few kilometers. The POPS II U system performance improvement objectives will optimize DOD METOC support in the following specific areas:

- Long and near real-time period METOC support for warfighter planning/decisions
- Aircraft routing services
- Safe and direct ship routing services
- Hurricane, typhoon and tropical storm prediction
- Open ocean and coastal wave prediction
- Precipitation prediction
- Refractivity conditions/ducting range
- Acoustics support
- Ballistic missile targeting support
- Search and rescue
- Chemical/biological/nuclear transport prediction

Distributed Atmospheric Modeling Prediction System (DAMPS)

For centuries, military commanders have looked to the weather for tactical advantage. The Navy is currently the nation's only military service that operates a distributed model in support of tactical weather prediction. DAMPS allows users to ingest high-resolution data and on-scene observations into regional and global model information received from the Fleet Numerical Meteorology and Oceanography Center in Monterey, California. The result is an on-scene weather model that provides accurate weather predictions for an operating area within a 24-hour timeframe.

DAMPS uses real-time weather data from ship and battle group observations, including parameters such as wind, temperature, cloud, visibility and radar data, and then incorporates this data into its analysis. This analysis can be highly focused on any area of interest.

Naval Integrated Tactical Environmental System (NITES)

The Navy continued migration towards a modular, interoperable suite of systems to ingest, process, fuse, display, and disseminate METOC information and its impact on tactical operations. The program currently consists of four seamless versions known as NITES Versions I-IV. NITES will be fielded through FY 2006. Navy is reviewing various options for the follow-on system to NITES. The four NITES versions are:

- NITES I. Provides Navy decision-makers on major combatant ships with METOC assessments and forecasts, and integrates data with sensor and weapon platform parameters for system performance assessments. Theater METOC Centers use NITES I to provide value-added products to fleet units, and the numerical prediction guidance generated by FLENUMMETOCCEN.
- NITES II. Makes METOC data and products available to Navy and Marine Corps activities afloat and ashore via the Global Command and Control System-Maritime (GCCS-M). The NITES II Object Oriented Redesign (OOR) is the basis for the Joint METOC Segment of the new Global Command and Control System (GCCS) V4.0.
- NITES III. An unclassified forecast, briefing, and display system tailored to Naval METOC shore activities in support of aviation operations.
- NITES IV. A portable system tailored to Mobile Environmental Team (MET) and USMC Meteorological Support Team (MST) METOC requirements.

Tactical Environmental Data Server (TEDS)

TEDS is a storage and data management system for meteorological, oceanographic and environmental information whose architecture is built around the Informix relational database management system (RDBMS). It is the central engine in both the Tactical Environmental Support System (TESS) and the Navy Integrated Tactical Environmental System (NITES), providing data access support to the full spectrum of client applications and METOC models. The METCAST automated delivery software is used to facilitate the subscription of new and updated TEDS data, and the continuous on schedule transport of TEDS data to client tactical decision aids, and applications by means of the Internet (Figure 3-DOD-18).

Tactical Environmental Data Services (TEDServices)

TEDServices extends TEDS into the era of Net Centric Warfare (NCW), Sea Power-21, FORCEnet, Task Force Web, and the Navy Enterprise Portal (NEP) by means of a new Web Services architecture as described in the Oceanographer of the Navy's Operational Concept 2002. TEDServices provides a Data Oriented Service (as defined by the Navy Enterprise Application Developers Guide (NEADG)) that supports both the management and the bi-directional transport of meteorological, oceanographic and other environmental information. The TEDS original RDBMS architecture is being replaced with a lightweight, forward deployed, data cache, which offers warfighters, METOC professionals, TDAs/applications and weapon systems immediate access to the Virtual Natural

Environment (VNE). The VNE is a 4-dimentional representation of the user-defined battlespace environment. TEDServices' Clients will use a new METOC Mission Rules Based Data Order (MRBDO) process to subscribe to relevant data by mission, platform, TDA/application, parameter or product. The design tenants of TEDServices include: Data Transport (to reduce bi-directional bandwidth use), Data Management (to simplify data ordering and forwarded deployed data administration), Data Representation (to implement a unified Geospatial Coordinate Process), and DOD Joint Interoperability (to support standards defined by the Joint METOC Interoperability Board).

Environmental Satellite Receiver-Processor (AN/SMQ-11 and AN/FMQ-17)

These systems are the principal Navy systems to acquire environmental data directly from satellites. There are different equipment configurations for ships (AN/SMQ-11) and shore sites (AN/FMQ-17), and through their interface with NITES variants they provide remotely sensed information to the operator. The AN/FMQ-17 is capable of receiving direct downloads from geostationary and polar orbiting satellites, while the AN/SMQ-11 receives only polar orbiting satellite data directly.

Automated Surface Observing System (ASOS)

ASOS, a joint DOD, DOC, and DOT leveraged program, supports aviation and local area observing requirements at Navy and Marine Corps stations worldwide. ASOS helps assimilate field meteorological parameters and facilitates efficient entry of surface aviation observations and synoptic weather reports into national numerical models. NAVMETOCCOM has certified a number of ASOS units at local and remote USN/USMC airfields for stand-alone use during off-duty hours, when observers are not present to verify the official station observation.

Figure 3-DOD-17. Flight deck personnel work to secure Carrier Air Wing Nine (CVW-9) aircraft during a rainsquall aboard USS CARL VINSON (CVN 70) while operating in the vicinity of the Marianas Islands (United States Navy Photo)

Supplemental Weather Radars (SWR) (AN/FPS-131 and AN/TPS-76)

The Navy has Supplemental Weather Radars to provide Doppler weather radar coverage at selected Navy and USMC sites, mostly overseas, outside of NEXRAD coverage.

Meteorological Mobile Facility Replacement (METMF(R))

The METMF(R) is a transportable system that houses meteorological support equipment for the Marine Air Ground Task Force (MAGTF). This 8 x 8 x 20 foot van provides a fully functioning weather office designed to support Marine Corps expeditionary airfield operations for 30 days without resupply. It includes sub-systems for data collection (local, remote and upper air sensors), data processing, satellite data ingest and display, Doppler radar, communications, briefing support, and support for remote forces. The METMF(R) is interoperable with the Marine Corps C4I systems and METOC systems of the other Services via the Global Command and Control System (GCCS).

Naval Flight Weather Briefer (NFWB)

Naval Flight Weather Briefer (NFWB) is a remote, web-based aviation weather briefing application that can be used to provide formal DD Form 175-1 and multiple established ("designated route") military weather briefings. NFWB also provides pilots with real-time weather briefings direct to their ready-room or any web-browser worldwide.

NFWB allows United States Navy and Marine Corps aviation forecasters and pilots to simultaneously view the same brief and value-added weather graphics during briefings. Additionally, NFWB provides pilots with computer generated DD-175 Military Flight Plans or DD-1801 International Flight Plans for electronic submission to base Air Operations. A global alphanumeric database is also available to both the pilot and forecaster for the retrieval of Meteorological Terminal Aviation Routine Weather Reports (METAR observations) and Terminal Aerodrome Forecasts (TAFs) by Station Identifier. Strategically located web and data servers host the NFWB software, web-based applications, and historical databases. Pilots, forecasters, and Air Operations personnel simply login through an NFWB web-interface.

Operational Products and Services

Optimum Track Ship Routing (OTSR) and Optimum Path Aircraft Routing System (OPARS) are advisory services for fleet units. They are based on NOGAPS, COAMPS and wave forecast data, are tailored to the customer, and provide guidance to the forecaster for the safe operation and cost-effective routing of DOD ships and aircraft, just as they have for nearly 30 years. OTSR and OPARS save the operating forces of all services approximately $57 million/year in

reduced fuel consumption and personnel costs.

The Navy METCAST/JMV system is a PC-based software package used to make FLENUMMETOCCEN numerical products available to front line DOD users. All standard meteorological and oceanographic fields, synoptic observations and basic DMSP satellite imagery are also available.

MyWxmap ("My Weather Map") is a web-based service from FNMOC that allows military and civilian users worldwide to access numerical output of selected weather parameters throughout the world. Because of continually emerging Internet technology, a large subset of these products can also be made available to the general public at no additional cost. It will eventually be integrated into various Web portals now under development.

Since 1983, the Naval Regional Meteorology and Oceanography Center, in Norfolk Virginia has provided long-range forecasts in support of Energy Conservation efforts at Naval shore installations in the continental United States. The services are primarily in the form of extended-range (10 day) temperature forecasts provided to energy managers to assist in optimizing power plant operations. Monthly temperature/degree day outlooks and long-lead (12 month) seasonal and precipitation forecasts are also issued to assist in strategic planning of fuel purchasing and resource allocation. Documented savings from the Energy Conservation Forecast Program exceed $62 million, with the majority of savings resulting from power plant steam/air conditioning on/off recommendations and energy resource/fuel allocation based on long-lead forecast products. The program has recently added a Pier Load Forecast that is used by four Naval Stations to help predict ship power requirements. Customers include 128 Navy and Marine Corps facilities and commands.

SUPPORTING RESEARCH

The Navy administers a diverse research and development (R&D) program, ranging from software development to sensor engineering, and processing, display, and distribution devices. Application of R&D activities of other Services and federal agencies is always considered, and use of existing government and commercial off-the-shelf items is emphasized.

The Navy is a world leader in the field of numerical weather prediction for marine environmental services. Transitioning fundamental scientific research, through additional development, into operational meteorological and oceanographic models is key to a successful numerical prediction program. This ongoing process includes work at universities and the Naval Research Laboratory's Marine Meteorological Division to keep the Navy Operational Global Atmospheric Prediction System (NOGAPS) and the Coupled Oceanographic and Atmospheric Mesoscale Prediction System (COAMPS) at the leading edge of technology. Development is also underway to improve data assimilation, quality control, and management techniques to support these models. The Navy's suite of models also includes phenomena such as waves, tides, ice, tropical cyclone, and biological/aerosol transport.

The Navy R&D program in remote sensing develops techniques to extract tactically significant information in the littoral regions of the world. Sensors aboard existing satellites are exploited to the greatest extent possible and plans are in place to incorporate new capabilities when introduced. Because many satellite-processing algorithms are designed for use with tactical systems, expert or rule-based processes are used where possible to reduce human-intensive interpretation.

INTERAGENCY COOPERATION

Navy and Air Force have long been cooperating in DOD weather support, and these efforts have led to such successes as the Defense Meteorological Satellite Program and the Joint Typhoon Warning Center. Recently, the two services have reinvigorated efforts to increase efficiencies in their METOC programs through greater cooperation, particularly in the area of support to military Command and Control (C2) and Intelligence, Reconnaissance, and Surveillance (ISR) systems. Working groups under the direction of the Joint METOC Interoperability Board (JMIB) continue to develop a road map to build an authoritative Four Dimensional Data Cube (4-D Cube) for weapon and sensor systems, accelerate the development of common data base segments and API's, and develop a common mapping tool kit. All of these efforts are designed to ensure consistent, accurate, relevant, and timely information for both automated and human-in-the-loop planning and decision systems.

To maximize efficiency and benefit for Navy and NOAA cooperative activities, an Umbrella Memorandum of Agreement (MOA) between these two agencies was updated and recently signed in early 2004. Both agencies continue to identify new areas of potential cooperation and review existing agreements for conversion into annexes to this MOA. Specific areas include:

- Cooperative efforts in operational numerical modeling, data exchange, and mutual backup between FLENUMMETOCCEN and the National Centers for Environmental Prediction (NCEP).
- Navy/NOAA/Coast Guard operation of the National Ice Center.
- Cooperative efforts between FLENUMMETOCCEN and the Pacific Fisheries Environmental Laboratory of the National Marine Fisheries Service.

- Air Force Weather Agency (AFWA) / Navy (FLENUMMETOCCEN, NAVOCEANO) / NOAA-NESDIS agreement on shared processing of satellite data.
- Navy/NOAA agreement on ASOS procurement and installation.
- Satellite altimetry data processing.
- Training cooperation through Cooperative Program for Operational Meteorology Education and Training (COMET).

MOAs also exist between the Department of Commerce, Department of Transportation, and the Department of Defense concerning procurement and operation of NEXRAD. Additionally, Navy is a DOD participant in the development of the DOC/DOD/NASA converged National Polar-orbiting Operational Environmental Satellite System (NPOESS).

Natural Disaster Mitigation

Navy METOC plays a vital role in reducing the impact of natural disasters to units both ashore and afloat. Severe weather warnings are issued at Naval facilities by the local NAVMETOCCOM activity when conditions warrant. For ships operating at sea without METOC personnel embarked, tailored enroute weather forecast messages (WEAX) and high winds and seas warnings provide commanding officers with advance notice of heavy weather, and Optimum Track Ship Routing (OTSR) forecasters monitor ship movements and provide heavy weather avoidance recommendations.

Tropical cyclones and even severe winter storms provide even greater challenges, as ships cannot generally "ride out" storms in port without sustaining damage. Similarly, once they get underway (or "sortie") ships must steer well clear of the highest winds and seas, to avoid personnel injuries and damage and ensure their stability limits are not exceeded. Storms of little consequence to the general public - those that remain well out at sea - are still of great concern to the Navy. Because of the need to sortie ahead of tropical cyclones, the Navy must make decisions 3 to 5 days in advance of potentially dangerous weather. Sortie decisions are extraordinarily difficult to make because of their high cost and impact on personnel and operations. In making these decisions, Fleet commanders must strike a balance between the risks of staying inport versus the cost and potential for damage at sea. Additionally, naval exercises and ship transits are often placed at risk by multiple tropical cyclone events, which can make successful evasion extremely difficult.

Forecasts are provided to the fleet commanders and their staffs by the nearest NAVMETOCCOM activity and/or afloat METOC personnel. Within CONUS and adjacent ocean areas, tropical cyclone forecasts in particular are closely coordinated with those of the National Weather Service. Overseas, local tropical cyclone warnings and forecasts are based on guidance provided by the Joint Typhoon Warning Center (JTWC), Pearl Harbor, Hawaii. The Commander of the United States Pacific Command designated FLENUMMETOCCEN as the alternate JTWC.

ARMY TRANSFORMATION

The United States Army is undergoing a historical transformation from a division-centered Army poised to fight a cold war, to a smaller, brigade based Army ready to engage in any conflict around the globe. Not only is today's threat to our security more complex and more unpredictable than that of the past, but it is one that could also arise anywhere in the world. To meet this threat, the Army's Campaign Plan addresses three major areas:

- create a modular Army
- restructure the force, and
- stabilize that force.

Modularity will be the most visible aspect of Army transformation to the weather community at large. Modular units will be more compact and more deployable than the current division sized unit. Instead of deploying at the division level, the future force will deploy as brigade units of action. Each unit of action will be self-contained and self-sustaining. This modular Army will fight jointly with other services and with coalition forces. The modular Army will also be an expeditionary force, capable of deploying anywhere in the world and engaging any type of opposing force.

This transformation to a modular Army dictates changes in both weather support requirements and the means by which weather is provided to units of action. Weather teams will be resized and will rely more on "reach back" capabilities to obtain pertinent meteorological data. The Army and Air Force are working together to determine the optimal weather team sizing, equipment and communications capabilities required to support these new modular units of action.

OPERATIONAL EQUIPMENT AND SUPPORT MISSIONS

Although it is transforming to a modular force, the existing weather support structure within the United States Army is a mix of Army and United States Air Force (USAF) personnel and equipment according to Army-Air Force agreement (Army Regulation (AR) 115-10/Air Force Joint Instruction (AFJI) 15-157, *Weather Support for the United States Army*, 30 June 1996). This joint regulation describes the Service responsibilities and those of Major Army Commands (MACOMs) within the Army for providing weather support. The United States Army provides direct weather support to two Army missions: upper air observations for Field Artillery fire support, and limited surface weather observations to support Army weapon systems forward of Division tactical operations centers (Figure 3-DOD-18). Air Force (AF) Major Commands (MAJCOMs) provide operational weather services to war fighting MACOMs in combat, contingencies, and peacetime training. United States Army Forces Command (FORSCOM), United States Army Europe (USAREUR), United States Army Pacific (USARPAC), United States Army Special Operations Command (USASOC), Eighth United States Army (EUSA), and United States Army Training and Doctrine Command (TRADOC) have AF Weather personnel providing daily installation and tactical weather support. Army Artillery Meteorological (ARTYMET) Crews provide direct upper air observation support to artillery units in the same MACOMs. During peacetime training and activation, the Air National Guard (ANG) provides AF operational weather support to the United States Army Reserve (USAR) and Army National Guard (ARNG), collectively designated the Reserve Component (RC). In addition, during exercises and contingencies, the ANG may augment the active Army Combat Weather Teams (CWTs).

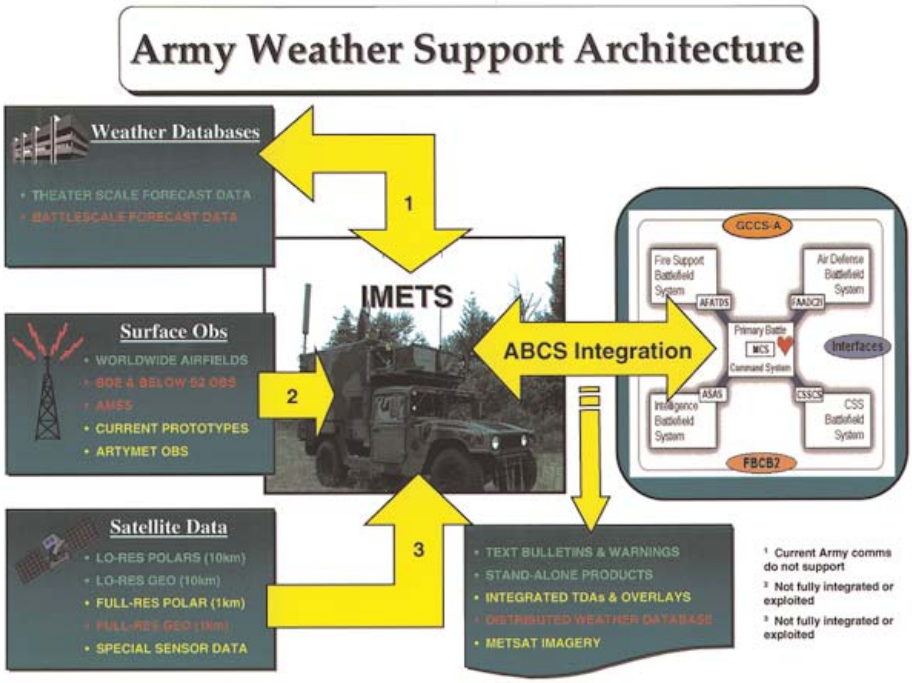

Figure 3-DOD-18. Army Weather Support Architecture

The Army also provides the operational weather support to Army Research Development, Test and Evaluation (RDTE) ranges, centers, and other research facilities using the Developmental Test Command's (DTC) Meteorological Teams (MET

Figure 3-DOD-19. Accurate wind profiles are essential for the Artillery to engage their targets (United States Army Photo).

Teams) and United States Army Space and Missile Defense Command (SMDC) contractors. DTC operational support is established under Army Test and Evaluation Command. SMDC provides weather support to the Ronald Reagan Ballistic Missile Defense Test Site at Kwajalein Atoll through a Meteorological Environmental Test Support contractor.

The Army provides the tactical field and communications equipment to USAF CWTs for tactical operations. The Integrated Meteorological System (IMETS) is the United States Army's tactical weather communication, intelligence, and information system providing digital weather support to the commanders and staffs of tactical units, from Echelons Above Corps (EAC) to aviation battalions. The Project Director for IMETS (PD, IMETS) falls under the direction of the Project Manager, Intelligence and Effects and the oversight of the Program Executive Officer, Command, Control, Communications - Tactical (PEO C3T). The Communications and Electronics Command (CECOM) and Army Research Laboratory (ARL) provide fielding and technical support to PD, IMETS and to Field Artillery meteorology programs.

ARTYMET Crews are assigned to Artillery units at Division level, to Field Artillery Brigades, and to Separate Brigades with a direct support Artillery Battalion. Army soldiers regularly take tactical upper air observations to support Field Artillery units during tactical training exercises, at permanent Army Artillery Ranges, or during the full range of combat missions. ARTYMET Crews also take limited surface observations at tactical locations on an "as needed" basis to support artillery operational requirements.

ARTYMET Crews in the Active Component (AC) and RC sections currently use the Meteorological Measuring Set (MMS), AN/TMQ-41, to take upper air observations during tactical operations. It is a mobile, upper air sounding system mounted on a High Mobility Multipurpose Wheeled Vehicle (HMMWV). The MMS provides upper air data to the Field Artillery Tactical Data System for use in adjusting artillery fire, to USAF CWTs, and to the Chemical Officer for use in smoke and in Nuclear, Biological and Chemical (NBC) defense operations (Figure 3-DOD-19). The United States Army Field Artillery School (USAFAS), Fort Sill, Oklahoma, develops requirement documents and is the combat and training developer for meteorological equipment used for Field Artillery support.

The Army provides supplemental, limited surface observations when required in tactical situations to support Army operations. When directed by the Intelligence Officer (S2), Intelligence personnel in the forward combat areas take these observations.

Headquarters, Department of the Army, Office of the Deputy Chief of Staff, G-2, is responsible for Army weather support policy. The Office of the Deputy Chief of Staff, G-3, is responsible for validating and prioritizing weather support requirements and programs to meet Army requirements. In addition, an Army Intelligence Officer at the Air Force Weather Agency (AFWA) at Offutt AFB, NE, serves as a consultant to AFWA for Army weather requirements.

Army Operational Support provided by the Air Force

Under AR 115-10/AFJI 15-157, the AF is responsible for providing the Army with the necessary manpower and unique tactical and fixed weather equipment to meet Army tactical and garrison active component (AC) and reserve component (RC) support requirements. Army support manpower requirements are sourced from AF active, reserve, and ANG weather units. While direct support of the Field Artillery remains an Army responsibility, and is supported by Army ARTYMET teams, AF CWTs provide supplemental information to artillery crews in contingencies for areas beyond direct ARTYMET observation capabilities. The AF assigns AF weather personnel to the war fighting MACOMs at theater, corps, division, armored cavalry regiments, aviation brigades, separate brigades, and special forces groups/ranger regiments to provide direct, on site weather support. AF Operational Weather Squadrons (OWSs) and Combat Weather Teams (CWTs) provide garrison and tactical weather warning, observing, forecasting, special support, and staff weather officer (SWO) services to Combat, Combat Support, and Combat Service Support units throughout the peacetime/war continuum (Figure 3-DOD-20). Peacetime garrison activities include supporting flying operations at Army Airfields and severe weather watch, warning, and advisory services for aircraft and post resource protection. The AF is responsible for installation, operation, and maintenance of standard AF meteorological and observing equipment at Army Airfield Weather Stations. Tactically, the Army is responsible for vehicles, tactical communications, and weather effects criteria. The Army's Integrated Meteorological System (IMETS) is fielded for these purposes and is operated by AF CWTs. The Army also maintains IMETS hardware and software, with

the AF maintaining AF software that performs meteorological functions within IMETS. IMETS uses AF meteorological software, but IMETS is hosted on an Army vehicle, uses Army tactical communications and Army weather effects software. IMETS baseline software is hosted on Army Common Hardware and is Defense Information Infrastructure Common Operating Environment (DIICOE) and Joint Technical Architecture - Army (JTA-A) compliant. The Army provides other tactical equipment to AF CWTs through an Army Table of Organizations and Equipment (TOE). The following paragraphs describe weather activities within Army MACOMs.

Eighth United States Army

USAF weather personnel assigned to the 607th Weather Squadron (607 WS) provide fixed and tactical weather support to 8th United States Army units. 607 WS provides garrison and tactical weather observing, advisory, mission forecast, special support, and staff weather officer services during contingency, exercise, and armistice operations. 607 WS units provide direct, on-site support at eight 8th United States Army installations and at deployed locations. Support is focused on air, ground, special operations, and other combat and combat support missions. In late FY 2002, 607 WS transferred armistice theater forecast responsibility to the 20th Operational Weather Squadron (20 OWS) at Yokota Air Force Base in Japan. The 8th United States Army Combat Weather Teams are now primarily responsible for providing their customers with observations and tailored mission execution forecasts based on 20 OWS overarching forecasts. Lead METOC support during exercises and contingencies remains with the 607 WS Combined METOC Forecast Unit, in close coordination with 20 OWS. In FY 2005, 607 WS will continue to provide 78 trained weather personnel and will require fixed and tactical weather sensing, data processing, and communications equipment. 8th United States Army provides USAF weather units needed garrison and tactical communications, tactical vehicles, MTOE and CTA equipment, and operating funds (for expendables, maintenance, etc.) IAW AR 115-10/AFJI 15-157 (June 1996).

United States Army Europe and Seventh Army

United States Army Europe (USAREUR) and 7th Army require and use Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating limited surface weather observations to support all tactical units and operations.

The Air Force's 7th Weather Squadron (7 WS) provides USAREUR/7th Army in-garrison and tactical weather intelligence and support. This includes observing services for in-garrison operations, contingency and exercise operations, staff weather officer services, and specialized support. The United States Air Forces in Europe (USAFE) Operational Weather Squadron at Sembach AB, Germany, provides operational-level forecast products for the European Command Area of Responsibility, to include all USAREUR units. Combat weather teams located at V Corps and its aviation assets, 1st Infantry Division and its aviation brigade, 1st Armored Division and its aviation brigade, Southern European Task Force, and 7th Army Training Command, as well as 7 WS supporting 7th Army, evaluate and tailor these forecast products to produce mission execution forecasts.

The mission of 7 WS and its 11 detachments and operating locations is to provide weather operations packages to conform to the Army's garrison and war operations. Additionally, 7 WS provide weather operations to meet future Army transformation and modularity initiatives. 7 WS will match the deploying weather force structure to the mission that USAREUR is called upon to execute. 7 WS will utilize "reachback" capabilities to the maximum extent possible to minimize the deployed footprint without compromising weather operations.

Seven IMETS have been fielded within USAREUR (V Corps, two divisions and their aviation brigades, and two separate brigades. The IMETS is geared to interface as a module of the Army Battlespace Control System to inject weather decision products into the common battle picture for Army commanders. IMETS Light (IMETS-L) version will be fielded in October FY 2005 to Aviation Brigades. This version is designed to mirror the capabilities of the IMETS Vehicle mounted configuration currently fielded, but is much more flexible and more easily deployed.

USAREUR provides supporting USAF weather teams with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operating funds (expendables, maintenance, etc.). Four ARTYMET sections collect upper air observations for direct use by field artillery units. The Forward Area Limited Observing

Figure 3-DOD-20. Reliable wind forecasts are necessary to ensure safety during airborne operations (United States Army Photo).

Program (FALOP) consists of Army personnel taking limited observations at forward areas in the battlespace.

United States Army Special Operations Command (USASOC)

Weather support to USASOC allows commanders to improve efficiency, effectiveness and safety of operations for USASOC units. USASOC personnel use tactical weather kits to collect limited weather data and provide limited scope meteorological observations from permissive, semi-permissive and uncertain environments in direct support of the Army. Army Special Operations Forces collect weather data at the deployed team level. These observations are passed to operating bases for use by Army commanders and staff, as well as Air Force Special Operations Command (AFSOC) and Air National Guard (ANG) weather personnel. AFSOC personnel providing direct support to USASOC units are assigned to the 10th Combat Weather Squadron (10 CWS), OL-A, 320 Special Tactics Squadron (STS), OL-A 321 STS, and OL-A 353 Special Operations Group. ANG personnel providing direct support to USASOC when activated are assigned to the 107th Weather Flight, Michigan ANG, 146th Weather Flight, Pennsylvania ANG, and 181st Weather Flight, Texas ANG. These weather units provide garrison and tactical support to USASOC units including the United States Army Special Forces Command and its seven subordinate Special Forces Groups (SFC); the 75th Ranger Regiment, the 160th Special Operations Aviation Regiment, the United States Civil Affairs and Psychological Operations Command (USCAPOC); and all SFG and regimental subordinate battalions, and two separate aviation companies. Support provided includes: climatology and solar/lunar illumination tables and studies; courses of action and mission impacts analysis; weather watch/warning services; mission execution forecasts; flight weather briefings; drop/landing zone forecasts; training to Army Special Operations Forces; training of host nation and indigenous forces on conducting limited observation programs; surface, upper-air and tactical radar observations; and Foreign Internal Defense analysis, surveys and training. AFSOC Special Operations Weather Teams (SOWTs) provide the DOD's sole source for high-fidelity Meteorological and Oceanographic (METOC) intelligence data collection from austere, denied, hostile or semi-permissive areas of the battlespace. AFSOC provides staff weather support to USASOC, United States Army Special Forces Command (Airborne) and the United States Army John F. Kennedy Special Warfare Center and School.

USASOC plans and expends resources for operational and administrative support to Air Force Special Operations Command SOWTs providing meteorological service support to USASOC components. USASOC provides funding for required training beyond standard AF weather training, office and deployable automation systems and connectivity to local networks; dedicated tactical communications systems; operations and maintenance/sustainment to support USASOC requirements; funding for Temporary Duty for USASOC requirements; and some organizational clothing and individual equipment. Additionally, USASOC covers expenditures for tactical equipment items such as NBC equipment; communications; Army developed and procured meteorological equipment, power, vehicles, and life support equipment required to accomplish USASOC weather support missions; and maintenance and supplies for USASOC provided equipment. Seventeen IMETS-L have been fielded within USASOC. IMETS-L provides a mobile automated weather data receiving, processing and dissemination system to USAF Weather Teams supporting SOF. IMETS-L also provides digital weather support, real-time tailored weather information, forecasts, and weather effects on friendly and hostile weapons systems. USASOC also provides funding for facilities, office space, office furniture, and real property to house supporting special operations weather units, as well as secure storage of required equipment.

United States Army Pacific (USARPAC)

USARPAC uses Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating surface weather observations to support tactical units and operations. There are three subordinate commands within USARPAC: United States Army Hawaii (USARHAW), United States Army Alaska (USARAK), and United States Army Japan (USARJ).

USARPAC provides supporting USAF units with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operations and maintenance funds.

The IMETS and New Tactical Forecast System (N-TFS) have been fielded within USARPAC as the primary meteorological equipment for deployed operations. 25ID(L) was also given two IMETS-L units ahead of schedule for its yearlong deployment to Iraq. The IMETS and NTFS reachback for data via Army provided NIPRNET and SIPRNET conduits.

The 17th Operational Weather Squadron (17 OWS) provides HQ USARPAC with garrison and tactical weather warnings, forecasts, special support, and SWO services during contingencies and humanitarian operations. Additional Combat Weather Teams (CWTs) assigned to USARJ, USARHAW - including the 25th ID(L) - and USARAK, including 172 SIB,

provide direct, on-site support at 5 USARPAC installations. The CWTs also deploy with their customers providing tailored battlefield observations and forecasts. Weather reengineering has reduced the requirement for forward deployed weather personnel, instead leveraging IMETS and other recently fielded technology for reach-back capability. The 17 OWS provides regional weather support, allowing the forward deployed forces to focus on specific area and target forecasts.

The 20 OWS at Yokota AB, Japan, provides operational-level forecast products for the USARJ AOR, to include all USARJ units. A 20 OWS member serves as the USARJ's SWO. In addition, specific resource protection support (i.e. weather advisories, warnings, and watches) is provided for Camp Zama, Japan. An AF CWT assigned to the 374th Operational Support Squadron at Yokota AB is located at Camp Zama. It provides observational support and produces mission execution forecasts to support aviation operations.

The 11th Operational Weather Squadron (11 OWS) at Elmendorf AFB, Alaska, provides operational-level forecast products for the Alaskan Command AOR, to include all USARAK units (Figure 3-DOD-21). The Commander, 11 OWS, serves as the CG, USARAK's Staff Weather Officer. Additionally, 11 OWS is responsible for Terminal Aerodrome Forecasts for Fort Wainwright, along with resource protection weather support (i.e. weather advisories, warnings, and watches) for Forts Wainwright, Greely, and Richardson. The 11 OWS provides flight weather briefing support, as required, to Army, Army Reserve, and Army National Guard aviation assets in theater. An AF CWT (3 ASOS/WE) is collocated with the 172d Infantry Brigade (Separate) (172d Stryker Brigade Combat Team (172 SBCT) at Fort Wainwright and the aviation assets of 4th Battalion, 123d Aviation Regiment. The 3 ASOS/WE provides weather support for both tactical and garrison operations, observes the atmosphere and evaluates, then tailors, forecast products to produce Mission Execution Forecasts and staff briefings. After the SBCT conversion, 172 SBCT will include tactical unmanned aerial vehicles (T-UAVs), whose operators will also be receive their weather support from 3 ASOS/WE. The Alaska Army National Guard operates the airfield at Fort Richardson.

Figure 3-DOD-21. Weather awareness is critical in situations such as this survival skills training exercise in Alaska. (United States Army Photo).

United States Army Forces Command (FORSCOM)

Weather support to FORSCOM is diverse and demanding. FORSCOM, the Army's largest major command, requires and uses Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating limited surface weather observations to support all tactical units and operations. FORSCOM consists of more than 750,000 Active Component (AC), United States Army Reserve (USAR) and Army National Guard (ARNG) soldiers. These soldiers account for more than 80 percent of the Army's combat power. FORSCOM trains, mobilizes, deploys, and sustains combat ready forces capable of responding rapidly to crises worldwide. The AC component of FORSCOM has nearly 200,000 soldiers. Third United States Army is the Army component of United States Central Command (USCENTCOM), which is the Joint command responsible for Southwest Asia (SWA), the Persian Gulf, and the Horn of Africa. United States Army South (USARSO) serves as the Army component to United States Southern Command (USSOUTHCOM). USARSO relocated from Fort Buchanan, Puerto Rico, to Fort Sam Houston, Texas, in 2003 and became a FORSCOM major subordinate command October 1, 2003. FORSCOM also commands three Army Corps: I Corps at Fort Lewis, Washington, III Corps at Fort Hood, Texas, and XVIII Airborne Corps at Fort Bragg, North Carolina. Together they include six divisions, two armored cavalry regiments, five separate brigades and a range of other corps combat, combat support and combat service support units. Two Continental United States Armies (CONUSAs), First United States Army and Fifth United States Army, are responsible for training, mobilization, and deployment support to Reserve Component units in FORSCOM. Another major subordinate command to FORSCOM, the United States Army Reserve Command (USARC), commands all United States Army Reserve units in the continental United States except those assigned to Special Operations Command. FORSCOM's Army Reserve strength stands at approximately 196,000 soldiers. USARC units are part of the Federal force and make their primary contribution to FORSCOM combat power in combat support and combat service support specialties such as medical, civil affairs, transportation, maintenance and supply.

The ARNG provides FORSCOM a balanced force of eight National Guard combat divisions, 15 enhanced separate brigades, extensive combat support, and combat service support units. The current FORSCOM ARNG strength is approximately 367,000 soldiers.

Weather support to FORSCOM's AA units comes from dedicated Air Force weather teams aligned under three AF Air Support Operations Groups (ASOGs) within Air Combat Command (ACC): 1 ASOG at Fort Lewis, Washington; 3 ASOG at Fort Hood, Texas; and 18 ASOG at Pope AFB, North Carolina. A weather squadron for each ASOG makes up the CWT. Each Army division has their own dedicated CWT. These CWTs are aligned under an Air Support Operations Squadron (ASOS) or one of the weather squadrons, at their respective installations. Corps and division CWTs are authorized personnel and equipment to support a variety of missions at the various Army echelons. Weather support at each Army echelon is provided according to Army Field Manual 34-81,/Air Force Joint Pamphlet 15-127, *Weather Support for Army Tactical Operations*. Currently, there are nearly 350 Air Force weather authorizations supporting various echelons across FORSCOM. These AFW personnel provide garrison and tactical weather warning, observing, mission execution forecast, special support, and SWO services during peacetime, combat, contingency, exercise, or armistice operations.

ACC weather units provide direct, on-site support at 11 major Army installations, including the National Training Center at Fort Irwin, California, and the Joint Readiness Training Center at Fort Polk, Louisiana, and at deployed locations. Support is focused on air, ground, special operations, and other combat and combat support missions.

FORSCOM provides supporting USAF units with a Modified Table of Organization and Equipment (MTOE) and operating funds (expendables, maintenance, etc.). ARTYMET requirements in FORSCOM are increasing from 17 to 26 sections in FY 2005 due to modularity. These 6-person sections, comprised of Army weather personnel, collect upper air observations for direct use by field artillery units.

The New Tactical Forecast System (N-TFS) is the primary in-garrison and tactical weather equipment for receiving graphics and alphanumeric data. Data is received via the Very Small Aperture Terminal (VSAT), Tactical VSAT (T-VSAT), Non-Secure Internet Protocol Router Network, and Secure Internet Protocol Router Network. The Small Tactical Terminal receives Geostationary and polar orbiting satellite imagery from the GOES, GMS, METEOSAT, DMSP, and NOAA meteorological satellites. Nineteen Integrated Meteorological Systems (IMETS) and 15 IMETS-Lights, developed by the Army Research Laboratory, have been fielded within FORSCOM. FORSCOM has also fielded commercial Automated Weather Observing Systems at Yakima Training Center Washington, Fort Campbell, Kentucky, and Georgetown Bahamas.

Training and Doctrine Command (TRADOC) Programs

Headquarters, TRADOC is responsible for the development and management of weather training programs, Army and Joint weather support doctrine (concepts and field manuals), and the establishment of requirement documents for Army tactical weather support. HQ TRADOC is the approval authority for Army-AF weather doctrine, Army weather system requirements, and weather support policy. Key mission area for the next few years will be to coordinate weather requirements as the Army transforms.

The IMETS continues as the state of the art Army weather forecast system. However, over the next few years its capabilities will be consolidated into the Air Force's Joint Environmental Toolkit (JET) program. The Army will retain research and development efforts related to Army weather support and responsibility for interfacing JET with Army Battle Command systems.

TRADOC Schools and Battle Laboratories:

The United States Army Intelligence Center and Fort Huachuca (USAIC&FH) is the functional proponent for Army tactical weather support. USAIC&FH represents the warfighter by collecting Army weather support requirements and developing solutions to satisfy those requirements. A key component to providing weather support to the Army is IMETS, fielded by the Army and operated by Air Force CWTs. The USAIC&FH Weather Team advises the USAIC&FH, ARL, and Air Force Weather (AFW) on Army weather support issues and helps develop solutions to meet both active and reserve forces' weather requirements. In addition, the USAIC&FH Weather Team monitors weather training to Intelligence and AFW personnel supporting the Army (e.g., the SWO Course and the Joint Intelligence-Combat Training Center). This year the USAIC&FH Weather Team was expanded to five members (three active duty Air Force plus two government contractors) to support the new expanded SWO Course. Over the last year, the USAIC&FH Weather Team helped provide weather support requirements as the Army transforms from the Current Force to the Future Force. The USAIC&FH Weather Team continued to update and expand the weather effects critical threshold value database to be incorporated into the Integrated Weather Effects Decision Aid (IWEDA).

Finally, they updated the IMETS requirements documents as the IMETS program went through several acquisition milestones towards approval by the Joint Requirements Oversight Council.

The Air Force Staff Weather Officer at the Army's Combined Arms Center (CAC) is the primary overseer of the Tables of Organization and Equipment for CWTs supporting Army operations. The CAC SWO also arranges for and provides environmental data, concepts of operation, and weather support guidance for various programs, projects, and studies conducted by the TRADOC System Manager for Army Battle Command System, the Battle Command Battle Laboratory-Leavenworth, and the TRADOC Analysis Center. Development of weather scripts and climatological packages to support modeling and simulation exercises of the Battle Command Training Program (BCTP), the Command and General Staff College (CGSC) and the National Simulation Center at Fort Leavenworth is another key CAC SWO task.

The United States Army Field Artillery School (USAFAS), Fort Sill, Oklahoma, is the proponent for upper air meteorological support to the Army. Artillery meteorological crews, Active and Reserve, used the AN/TMQ-50 to measure surface weather parameters. Tactical reliability issues forced an Army-wide 'STOP-USE' of the AN/TMQ-50 at the end of FY 2003. Artillery meteorological crews currently use manual surface instruments to measure surface weather conditions. The acquisition process has been initiated to identify a replacement for the AN/TMQ-50. The AN/TMQ-41 Meteorological Measur-ing Set (MMS) is utilized to take upper air observations. The MMS provides weather data to the Field Artillery Tactical Data System for ballistic calculations; to USAF CWTs for weather forecasting; and to the Chemical Officer for obscurant deployment, and Nuclear, Biological, Chemical (NBC) defense operations. TRADOC will work with USAFAS to ensure these surface and upper air observations are sent back to weather centrals where they can be ingested into the military's newest meso-scale models. Active unit's MMSs will be replaced by the AN/TMQ-52 Meteorological Measur-ing Set Profiler (MMS-P). The MMS-P is scheduled to begin fielding in early FY 2005. The MMS-P is a suite of meteorological sensors and associated software/models which will provide the Field Artillery with current and/or expected weather conditions at a point where the weapon munition is expected to engage a target (Target Area Met).

The Engineer School (USAES), Fort Leonard Wood, Missouri, coordinates weather support requirements for Terrain Analysis and Topographic Engineering. USAES develops methods of measuring and forecasting state of the ground for trafficability assessments using input weather data fields. Their mission also includes identifying, and documenting requirements to interface meteorological and engineer battlefield systems. Due to force cuts, USAES no longer has a full time civilian meteorologist in the Terrain Visualization Center, District of Columbia, but does have an instructor at the Terrain School at Fort Belvoir to teach weather effects on cross-country mobility and engineer missions.

The Army Aviation Center at Fort Rucker incorporates weather instruction and procedures into rotary-wing training programs in their mission areas. The Center has requirements for weather observations and USAF forecast support at Cairns Army Airfield, Troy Municipal Airport (MAP), Alabama, and Andalusia MAP, Alabama. Additionally, Fort Rucker operates observing and communications equipment to relay weather intelligence and resource protection advisories to numerous Army remote training sites. Two active duty positions are allocated to provide staff support for Army aviation and aviator training weather issues in areas of curriculum, concept development and doctrine.

In FY 2004, ACC civilianized day-to-day operational weather support to aviation operations at Fort Rucker and surrounding satellite airfields. Under the same contract ACCs provide weather observing and/or forecasting and briefing services for airfields at Fort Belvoir, Fort Benning, Fort Knox, Fort Leonard Wood, Fort Huachuca, and Fort Sill.

Army National Guard (ARNG) Artillery

The Army National Guard has 48 Meteorological Sections assigned to artillery units at Division level, Field Artillery Brigades, and in Separate Brigades. The ARTYMET sections provide upper air observations at least 39 training days each year supporting artillery live fire during Annual Training and monthly Inactive Duty Training. The ARTYMET sections support an average of 20 live fire training days and annually expend in excess of 100 balloons per section. The ARNG is in the process of modernizing to the Meteorological Measuring Set (MMS), AN/TMQ-41A.

Army Corps of Engineers Civil Operational Activities

The Corps of Engineers (COE) uses a network of about 10,849 land-based gauges. About 55 percent of the sites collect meteorological data, 35 percent a combination of hydrologic and meteorological data, and 10 percent hydrologic or water quality data. The Corps funds or partially funds 58 percent

(6,350) of all the gauges it uses. Meteorological gauges commonly measure precipitation and temperature as a minimum; most sites also measure hydrological data. All data are used in the regulation of COE dams and other water projects used for flood control, navigation, hydroelectric power, irrigation, water supply, water quality, and recreation. The COE transfers funds to NOAA/National Weather Service (NWS) to collect and maintain precipitation information from 826 of meteorological sites. Similarly, COE transfers funds to the United States Geological Survey to maintain precipitation data collection from 460 sites, while the COE maintains the rest. Seventy-five percent of all Corps sites provide real-time data via satellite, microwaves, meterbursts, landlines, or radio. Data from COE gauging sites are available to other federal, state and local agencies. The National Weather Service uses 100 percent of all Corps data. Most of the data is also used by other agencies.

United States Army Space and Missile Defense Command (USASMDC)

The High Energy Laser Systems Test Facility (HELSTF), an USASMDC directorate located on White Sands Missile Range, is an Army element of the DOD Major Range and Test Facility Base with the mission of high-energy laser (HEL) test and evaluation for future Army and sister Service HEL weapons. In addition to HEL systems test and evaluation, extensive use has been made of on-site laser systems to perform damage and vulnerability testing on laser-hardened materials, missile and aircraft components, and assorted battlefield equipment. The atmospheric sciences/meteorological mission is to support HEL testing by providing measurements of atmospheric conditions that are extremely important to propagation of any HEL beam through the atmosphere. Many unique meteorological instruments are maintained to support this critical data collection for HEL testing, including sonic anemometers, 32 meter towers for scintillometers, and a Lidar ceilometer (75,000 foot) one of 2 in North America (Figure 3-DOD-22). The HELSTF meteorological team also supports critical safety analysis of atmospheric dispersion for the very toxic laser fuels used.

United States Army Kwajalein Atoll (USAKA) is a subcommand of USASMDC, which provides operational support for the Ronald Reagan Ballistic Missile Defense Test Site (RTS). The RTS (Figure 3-DOD-23) meteorological services support contractor provides meteorological support for range activities including missile operations within the atoll, intra-atoll transportation (marine and aircraft), remote island missile launches including Wake Island, and emergency operations support.

A full suite of surface and upper air observing equipment is available to support of these operations. Three, fixed upper air sounding systems are located on Kwajalein and Roi-Namur (Figure 3-DOD-23). Two portable upper air systems can be deployed to remote locations to provide upper air soundings. Additionally, one polarimetric-Doppler S-band weather radar and one Doppler C-band weather radar, two DMSP/NOAA satellite receivers (one mobile) both having McIDAS display and management systems, one geostationary satellite receiver, and an intra-atoll mesonet and lightning detection network round out the sensors available to RTS forecasters. RTS, in cooperation with NASA/GSFC, continues to support global climate studies through the Tropical Rainfall Measurements Mission and the follow-on program of Global Precipitation Measurement and a smaller program of monitoring the solar-earth radiation flux for NOAA/ERL.

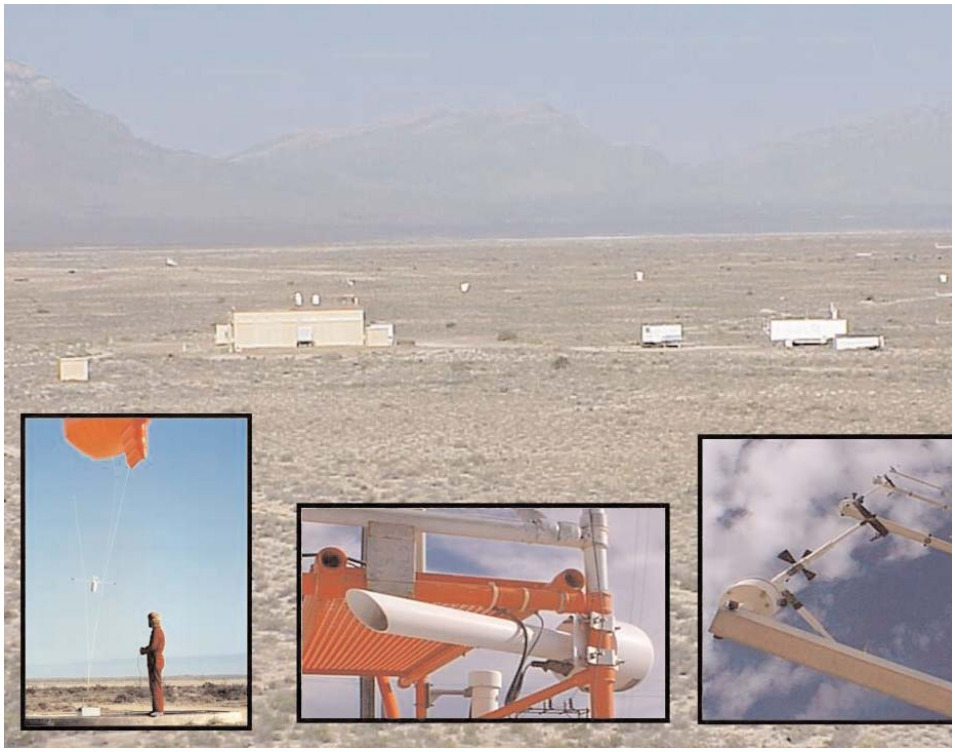

Figure 3-DOD-22. High Energy Laser Systems Test Facility (HELSTF) at White Sands Missile Range provides the Army with range and test facilities to conduct high-energy laser (HEL) test and evaluation for future weapon systems (United States Army Photo).

Figure 3-DOD-23. USASMDC is responsible for meteorological support to the Ronald Reagan Ballistic Missile Defense Test Site in the remote Kwajalein Atoll. (United States Army Photo).

WEATHER SUPPORT FOR RESEARCH, DEVELOPMENT, TEST, AND EVALUATION (RDTE)

Under Army-AF agreement, the Army has responsibility for weather support for research, development, test, and evaluation (RDTE) to support Army ground combat missions as specified in AR 115-10/AFJI 15-157. The Corps of Engineers (COE), and the Army Materiel Command (AMC) are the major contributors to weather research. The Medical Research and Development Command does research related to soldiers performance in the range of weather conditions expected to be encountered in all theaters of operations. The Army Test and Evaluation Command (ATEC) is responsible for operational meteorological support to Army RDT&E.

Corps of Engineers (COE)

The Corps of Engineers (COE) is responsible for reviewing all emerging Army systems for environmental effects, as stated in Army Regulation 70-1. The Topographic Engineering Center (TEC), and the Cold Regions Research and Engineering Laboratory (CRREL), of COE's Engineer Research and Development Center (ERDC), develop TDAs to interpret the impact of weather on terrain to enhance Army operations. TDAs are transitioned to the Digital Topographic Support System (DTSS).

Under its military mission, ERDC's Cold Regions Research and Engineering Laboratory, Hanover, NH provides support to Army weapon systems RDTE with climatological studies on the effects of winter and all-season environments on Army operations. CRREL conducts basic research in sensor signal interaction with snow, ice, and frozen soil, icing accretion on surfaces and structures, deicing technologies, and cold regions surface-air boundary process. CRREL develops databases and models predicting the state of the terrain supporting tactical decision aids such as mobility analysis and sensor performance. Other programs include weather effects on environmental research for military training lands, winter effects on acoustic sensors, mine detection, helicopter preflight deicing and airborne icing avoidance, and estimating snow water equivalence for predicting snow melt runoff and potential for flooding.

Meteorological forcing of soil climate is being used by CRREL researchers to investigate the use of broadband infrared imagery, spectral infrared measurements, and radar to detect mines; including surface mines, mines flush with the soil surface, and buried mines. Placement of mines flush with the soil surface and buried mines change the soil radiometric signature. Detection of this change could flag a potential mine location. Investigators were able to detect disturbed ground after mine placement using thermal infrared imagery. Figure 3DOD24 shows, in the left image, seven brighter, warm areas that are round mines and irregular areas of disturbed soil. Deeply buried mines are not readily detected by thermal infrared, but the disturbed soil from placing mines is detectable shortly after they are buried. One week later, as shown on the right image of Figure 3-DOD-24, areas of disturbed soil are no longer readily detected by thermal infrared imagery. Contrasts between disturbed and undisturbed soil have nearly disappeared as the soil becomes radiometrically uniform over time. Causes of these thermal contrasts, and the duration of detectable thermal contrasts in disturbed soil as a function of meteorological conditions, are under investigation.

Army Materiel Command (AMC)

The Army Materiel Command (AMC) is responsible for the design, development, test, and evaluation of equipment to satisfy requirements for meteorological support equipment. AMC provides climatological and meteorological support to RDTE projects involving electro-optics and obscurants. It is also responsible for determining weather effects critical threshold values and environmental sensitivities of battlefield systems. AMC has several Major Subordinate Commands (MSCs) and elements carrying out weather research and development responsibilities including the Research Development and Engineering Command (RDECOM), which has responsibility for the Army's Research Development and Engineering Centers (RDECs) and the Army Research Laboratory (ARL).

The Army Research Laboratory Battlefield Environment (BE) Division has an ongoing research program concerning flows within urban domains. This program focuses on fine scale meteorological fields in urban areas and the resultant transport of chemical-biological agents and other hazardous materials. The BE Division also is involved in multi-agency programs on the detection and characterization of chemical-biological agents.

The BE Division within the ARL Computational and Information Sciences Directorate (CISD), consists of three Branches and one Center. These span the two BE Division sites at Adelphi, Maryland, and White Sand Missile Range, New Mexico. The

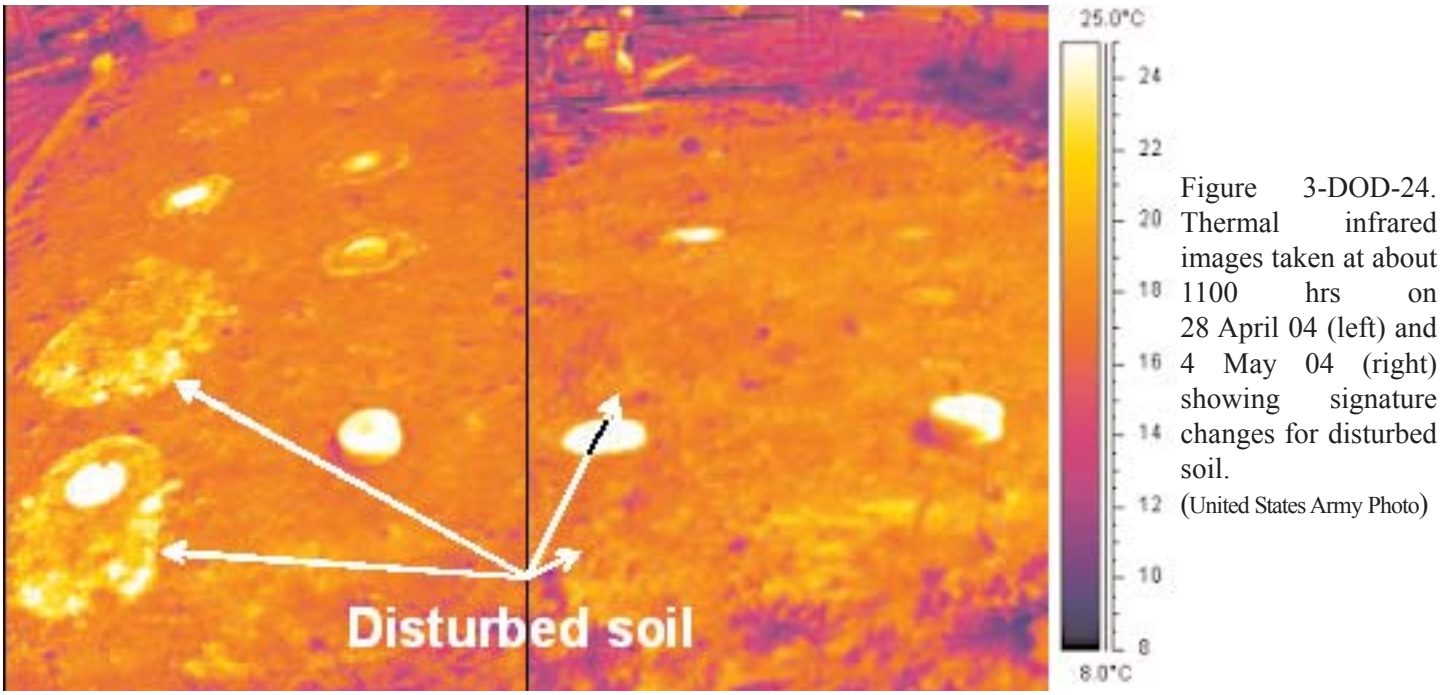

Figure 3-DOD-24. Thermal infrared images taken at about 1100 hrs on 28 April 04 (left) and 4 May 04 (right) showing signature changes for disturbed soil. (United States Army Photo)

three branches combine basic and applied research programs in the areas of meteorological modeling in complex terrain, atmospheric aerosols and contaminants, chemical/biological transport and dispersion coupling to planetary boundary layer processes, electromagnetic and acoustic propagation, advanced decision aids and high time/space resolution atmospheric characterization. The Center focuses on coordinating technology transition of BE Division products for support of Army weapons systems RDTE and weather intelligence technology for Battle Command and field artillery systems. In addition, the Center also provides liaison between Army weather R&D and the coupled programs at the AFWA, Air Force Combat Weather Center and the National Polar Orbiting Environmental Satellite System (NPOESS) Integrated Program Office (IPO).

The BE Division and the PD-IMETS office are partnering with the Air Force in new programs such as the development of a common Joint Environmental Toolkit (JET). The Army IMETS Weather Effects Workstation (WEW) and Air Force NTFS soft-ware baselines are to converge and transition into a single baseline JET, by the end of FY05. The JET baseline combines the AF forecast functions with the Army's weather impact Tactical Decision Aid applications and Army Battle Command System interfaces.

The Boundary Layer Meteorology Branch conducts a research program in the micrometeorological and mesoscale-gamma (small end of mesoscale) processes and structure of the atmospheric boundary layer at scales generally smaller than a few kilometers. This program focuses on the interaction of the land-air interface with wind fields, turbulence, and fluxes. Modeling of aerosol and chemical-biological transport and dispersion in the tactical environment are addressed, including detailed modeling of the boundary layer over complex terrain and within urban domains. A range of numerical weather models is addressed, including hydrostatic, non-hydrostatic and diagnostic gridded meteorological models. Diagnostic model output is combined with near real-time observations to produce rapid refresh analyses as part of the "Weather Running Estimate" being developed for the Army Future Force. These are verified against existing numerical weather prediction models and data.

The Army Research Office, Research Triangle Park, North Carolina, manages the Army's extramural basic research program in the atmospheric sciences. These programs are concerned with understanding the dynamical and physical processes of the atmospheric boundary layer at scales of interest to the Army (millimeters to 10's of kilometers) through measurements, simulations, and theoretical considerations. The basic research program is conducted through the peer-reviewed, individual investigator program and occasional special initiatives. The focus of the research is on the atmospheric processes and effects of the atmospheric boundary layer where the Army operates. Objectives of the research are to develop, from first principles, the physical basis for understanding the boundary layer processes, thereby leading to better understanding of atmospheric effects on soldiers, materials, and weapon systems. The research examines dispersion of battlefield materials, the effects of heterogeneous terrain features on airflow, and the develop-

ment of natural obscurations throughout the diurnal cycle. An essential element of the research is the development of instrumentation to measure the volumetric fields of wind velocity, temperature, and moisture of the boundary layer at turbulence time scales. Special funding areas are also managed. The Defense University Research and Instrumentation Program (DURIP) provides funds for instrumentation needed to support ongoing research activities. The Defense Experimental Program to Stimulate Competitive Research (DEPSCoR) participation is a competition restricted to universities in certain states that compete for additional basic research funds. Also basic research under the Small Business Innovative Research Program (SBIR) is managed for selected topics. A primary focus continues on the analysis and understanding of the stable boundary layer. New initiatives include acoustic tomography of the atmospheric surface layer and measurement and analyses of wind fields in an urban area.

Communications Electronics Command (CECOM), a major subordinate command of AMC, provides support to developing and fielding weather programs through the following organizations: Logistics Readiness Center (LRC), Research, Development and Engineering Center (RDEC), Software Engineering Center (SEC), and Safety office.

The CECOM LRC is the level II manager of the Meteorological Measuring Set (MMS) program. CECOM RDEC's Intelligence and Information Warfare Directorate provides technical management and support to the Program Manager, Intelligence and Effects and Program Manager, Night Vision/Reconnaissance, Surveillance, and Target Acquisition for the IMETS and the MMS-Profiler. A brief description of each of these programs shows CECOM's involvement.

Meteorological Measuring Set (MMS), AN/TMQ-41. The MMS is an upper air meteorological data collection, processing and dissemination system that provides data to the field artillery and target acquisition users. The system is a non-developmental item (NDI). All Army AC and RC units are equipped with the MMS. In FY 1995, MMS production and fieldings started and continued through FY 2003.

The Meteorological Measuring Set-Profiler (MMS-P) AN/TMQ-52 System. The Meteorological Measurement Set-Profiler (MMS-P) is a major improvement over the MMS. The AN/TMQ-52 design will support the new generation of artillery weapons. The system will include frequent and update meteorological messages that enhances the meteorological validity over a larger battle space than the current equipment. The MMS-P uses the MM5 mesoscale meteorological model to assimilate data from a variety of sources to provide the best meteorological messages to the user in a timely fashion. The system receives data from ground-based sources, radiosondes, and satellite-based sources, (such as boundary data from communications satellites and, in a future program block improvement, polar orbiting meteorological satellites) through onboard satellite receiving capability. The data affects the operation of the mesoscale meteorological model and for post-processing of the data in order to generate meteorological messages. Finally, an operator interface, in conjunction with the message generation and formatting software, facilitates communication between the MMS-P and all other systems that require interoperability with the MMS-P. Four System Design and Development (SDD) models have been produced. Developmental testing has been successfully completed and Low Rate Initial Production (LRIP) was approved in FY 2003. The Profiler system is currently scheduled for Initial Operational Test and Evaluation (IOTE) early FY 2005.

The Intelligence and Information Warfare Directorate (I2WD), Communications Electronics Research & Development Engineering Center (CERDEC), Research Development & Engineering (RD&E) Command provides technical and acquisition support to the Program Manager, Intelligence & Effects to develop the Integrated Meteorological System (IMETS).
The IMETS comes in two basic configurations known as the Vehicle Mounted (AN/TMQ-40B/C/D) and Light (AN/GMQ-36/36A/36B) groups. The IMETS Vehicle Mounted group has three variants, all with the same function that differ only by vehicle, shelter, and/or generator. The new IMETS-Light (AN/GMQ-36A) will replace the AN/GMQ-36 versions now in production with a CHS-3 cost savings window base computer. The AN/GMQ-36B is a Command Post version that has all the functionality of the AN/GMQ-36A.

Either the IMETS Vehicle Mounted (Figure 3-DOD-25) or the IMETS Light configuration can provide the weather component of the Intelligence Electronic Warfare (IEW) sub-element of the Army Battle Command System (ABCS). The IMETS provides commanders at all echelons with an automated tactical weather system that receives, processes and disseminates weather observations, forecasts, battlefield visualization, and weather effects decision aids to all Army Tactical Command and Control System (ATCCS) Battlefield Functional Areas (BFAs). IMETS can receive weather information from (either United States, European, Japanese, or Chinese civilian) geostationary satellites depending on the system's location, civilian forecast centers, the AFWA, artillery meteorological sections and remote sensors. IMETS processes and collates forecasts, observations, and climatological

Figure 3-DOD-25. IMETS Mounted Configuration. (United States Army Photo)

data to produce timely and accurate weather products tailored to the specific war-fighters needs. Significant weather and environmental support to war-fighters are the weather applications such as the automated tactical decision aids and contours client. These weather products display the impact of the weather on current or planned operations for both friendly and enemy forces. Weather products can also be overlaid on the Common Operational Picture (COP) or Common Tactical Picture (CTP) accessed by using a browser, and is executed on the users terminal through weather client implementations.

Currently Fiscal Year 2004 efforts are focused on: (1) ABCS 6.4 Good Enough (GE) and Intra-Army Interoperability Certification testing at the Central Test Support Facility (CTSF) and (2) Completion of the documentation and fabricating fabrication of the AN/TMQ-40C/D systems. Both of these systems, along with the AN/GMQ-36 are on schedule to field to units.

FY 2005 efforts will focus on the ABCS 6.4 GE Operational Assessment and fielding and the IMETS-Light (AN/GMQ-36A/B) Materiel Release and fielding decision, along with finishing the fielding efforts for the AN/GMQ-361 to gaining units including the Stryker Brigade. AN/TMQ-40B/C/D systems will also be fielded during FY 2005.

AMC's Field Assistance in Science & Technology (FAST) Activity provides rapid, successful technical solutions for the Warfighter. With Science Advisors (senior AMC scientists and engineers) located at Major Commands throughout the world, AMC-FAST provides support in a wide range of technical areas. Recently FAST was called upon to assist the 82d Airborne Division Artillery with identifying lightweight meteorological observation equipment. Currently, the 82d Division Artillery has units dispersed around the globe in support of the Global War on Terrorism. During the initial stages of deployment, these units had no MET measuring capabilities due to the gross weight and cumbersome size of their MET observation equipment.

AMC-FAST responded to this request by identifying a lightweight system called the Miniature Meteorological Observation Kit (Mini-Met Kit). The Mini-Met Kit is stored in a hard-shell case for protection during air drop, vehicular transport or storage. The three components of this kit may be removed from the hard-shell case and carried in one soldier's Alice Pack for dismounted operations. The kit consists of three pieces of equipment that allow ARYMET teams to observe current weather at the firing site and to launch and track pilot balloons (PIBALS) in support of artillery fires.

In their initial evaluation, the MET section of the 82d Division Artillery compared results obtained using the Mini-MET kit with those obtained from their older MET equipment. Results were reported to be in good agreement, with less than a 3 percent discrepancy in all readings taken. This new, lightweight weather observation kit will provide the 82nd Division Artillery with a MET capability that is parachute deployable by one trooper. In this manner, the Mini-MET Kit can truly be viewed as a force multiplier. As the XVIII Airborne Corps Field Artillery has a similar need for accurate, lightweight, man-portable meteorological equipment, AMC-FAST provided funding for 9 Mini-MET systems total; 4 to be evaluated in the field by the 82d Division Artillery and 5 by the XVIII ABN Corps Field Artillery. This evaluation is currently underway. It is anticipated that this AMC-FAST project will yield enhanced capabilities for the 82d Airborne Division Artillery and the XVIII Airborne Corps Field Artillery by providing them with a robust means to rapidly and accurately acquire the MET data needed to increase early entry artillery accuracy and lethality.

Army Test and Evaluation Command (ATEC)

The Developmental Test Command (DTC), a subordinate command of United States Army Test and Evaluation Command (ATEC), is responsible for providing operational meteorological support to eight Army ranges and test sites. Under responsibilities established in AR 115-10/ AFJI 15-157, the DTC meteorological units provide meteorological data collection and analysis, consultation, and weather forecast and warning services to support Army and other DOD research, development, test and evaluation (RDT&E) activities at the eight Army installations. Funding for the Army RDT&E Meteorology Program under Program Element 665702 is sufficient to maintain the basic meteorological support infrastructure at Army RDT&E ranges and sites. However, instrumentation needed to support unique or test-specific requirements generally must be funded by test sponsors. Because the majority of the operational meteorological support workforce at the Army ranges is or soon will be eligible to retire, the Program implemented a 2-year intern program in FY 2004 to recruit and train entry-level scientists and technicians to ensure continuity in specialized meteorological support services as senior employees begin to retire.

The Army RDT&E Meteorology Program has entered into a multi-year working relationship with the National Center for Atmospheric Research (NCAR) to enhance "range scale" (mesoscale to microscale) forecast and analysis technology. The principal product of this relationship is the Four-Dimensional Weather (4DWX) System, which consists of a central data archival/retrieval system for all range and external meteorological and model data, a high-resolution mesoscale meteorological model, and a variety of user-configurable displays. The mesoscale meteorological model, version 5 (MM5) is used operationally in both predictive and analysis modes to provide detailed information about the past, current, and forecast structure of the atmosphere over the Army's test ranges. Recent 4DWX enhancements include the implementation of MM5-based real-time four-dimensional data assimilation (RT-FDDA) capabilities at the major Army test ranges and development of Global Meteorology on Demand (GMOD), a globally-relocatable mesoscale modeling system to support Army RDT&E (including DTC Virtual Proving Ground modeling and simulation) at locations other than the Army ranges. Output from mesoscale model forecasts and analyses is used as meteorological input to atmospheric dispersion, noise propagation, ballistic trajectory, and other range applications models to simulate many tests and their associated impacts. The 4DWX system contributes to improved test planning and conduct, selection of more representative locations for test sensors, inclusion of realistic atmospheric effects in virtual testing, and forensic analyses of meteorological effects on test results.

The Chief of the Meteorology Division at Dugway Proving Ground's West Desert Test Center serves as the Program Manager for Meteorological Support to Army RDT&E. Under Program Element 0605384, the Division's Modeling and Assessment Branch also provides the following specialized services: (1) technical assistance to the DTC operational meteorological teams/branches; (2) atmospheric model verification and validation, including algorithm evaluation and the generation of validation data sets; (3) chemical/biological (CB) threat analysis studies for the Joint Contact Point (Project DO49); and (4) technical assistance to the DOD CB defense modeling community in the development of new CB hazard assessment models. Division employees also serve on various national and international committees addressing issues related to meteorological measurements, atmospheric dispersion modeling, and CB hazard assessment.

Army Medical Research and Materiel Command

The United States Army Research Institute of Environmental Medicine (USARIEM) conducts basic and applied research on the effects of heat, cold, high terrestrial altitude and nutritional status on the health and performance of individual soldiers and combat crews operating Army systems.

Applied research in thermal physiology and biophysical modeling is directed towards improving soldier performance and minimizing health risks in climatic extremes. The sensitivity of the soldier to local weather parameters (primarily ambient temperature, dew point, wind speed, and solar radiation) defines an operational envelope for unimpaired human performance. The overall goals of USARIEM weather-related research programs are to develop methods to effectively monitor and, where possible, extend the operational envelope for both training and operational scenarios.

Weather-related research efforts include the development and validation of automated methods to integrate thermal strain prediction models with real-time weather information resources relevant to dismounted infantry operations. Temporal and spatial scales of interest are meters to kilometers and minutes to several days. USARIEM is working with the Army Research Laboratory Battlefield Environment Division to implement thermal models on Personal Digital Assistant (PDA) devices and the Integrated Meteorological System (IMETS).

As part of the warfighter physiological status-monitoring (WPSM) program, USARIEM is investigating methodologies needed to integrate real-time local environmental data and warfighter physiological data with pre-

dictive model processes. The effective fusion of these two real-time data streams will enable near term environmental strain and performance status predictions for individual warfighters. Research efforts in this area are intended to address capabilities identified in the Operational Requirements Document (ORD) for the Army's Land Warrior program.

The availability of ground level environmental data at high temporal and spatial resolution continues to pose a significant challenge for predictive model development and validation. A Phase II Small Business Innovative Research (SBIR) project to design and build a very small wireless network-capable, expendable, micro-environmental sensing system has been expanded to consider new sensor applications, and the feasibility of on-body environmental sensors is also being investigated.